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Study on Effect of Nano Materials on Various Properties of Concrete

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Abstract : **Concrete composite is one of the main construction materials in civil engineering, with large quantities of it being consumed all over the world each year. Cement is an important raw material in the production of concrete composite. During the course of manufacturing of cement, large amounts of carbon dioxide (CO_2) get into the atmosphere. Approximately 77% of the anthropogenic Green House Gases is comprised of CO_2 and the current atmospheric concentration of CO_2 has reached 390 ppm, which is the highest ever recorded. So it is required to use a Green concrete that will result in the sustainable development without destruction of natural resources. The major objective behind green concrete is to reduce CO_2 emission from cement industry. Nano Material concrete is new generation concrete formed of materials of the grain size of Nano scale. The basic concept behind using Nano Material which are having large surface area is to improve compressive and flexural strength at early ages, improved hydration characteristics and reduced porosity and water absorption when compared with conventional cementitious materials.**

Keywords: Carbon Dioxide, Green Concrete, Green House Gas, Nano Material

1. INTRODUCTION

Amount of CO_2 emitted from the worldwide production of Ordinary Portland Cement (OPC) corresponds to approximately 7% of the total emissions into the Earth's atmosphere. The emissions of CO_2 in cement and concrete industry can be controlled by the incorporation of Green concrete in the mix design, without reducing the quality of the final product. One of the solutions for this global concern is the use of supplementary cementitious materials as a replacement for cement.

Green concrete can be defined as the concrete with material as a partial or complete replacement for cement or fine or coarse aggregates. The substitution material can be of waste or residual product in the manufacturing process and also could be a waste material that remain unused, that may be harmful. Green concrete should follow reduce, reuse and recycle technique.

The major objective behind green concept in concrete is to reduce Green house gas emission and also to reduce the use of natural resources such as limestone, shale, clay, natural river sand, natural rocks that are being consume for the development of human mankind that are not given back to the earth, and use of waste materials in concrete that also prevents the large area of land that is used for the storage of waste materials that results in the air, land and water pollution. Green concrete will result in the sustainable development without destruction of natural resources.

Nanotechnology can be used for design and construction processes in many areas since nanotechnology generated materials have many unique characteristics. These characteristics can again significantly fix current construction problems and may change the requirement and organization of construction process. The use of Nano materials like Nano-silica(NS), colloidal Nano Silica(CNS), Nano-Al2O3, Nano-TiO_2, Nano-ZnO, Nano-Fe_2O_3, Carbon Nano tubes(CNT), Nano Flyash(NFA), Nano cement, Nano silica fume(NSF) in the composition of cement, will result in significant reductions of CO_2 pollution and the use of performance thermal insulations will result in efficient use of energy for air conditioning. Currently, the use of Nano Materials in construction is reduced, mainly for the lack of knowledge concerning the suitable Nano Materials for construction and their behavior, the lack of specific standards for design and execution of the construction elements using Nano Materials, the reduced offer of Nano Materials, the lack of detailed information regarding the Nano Materials, high costs, unknowns of health risks associated with Nano Materials.

2. OBJECTIVE OF THE STUDY

- To analyze the effects of Nano Materials on the Different properties of concrete.

3. LITERATURE REVIEW

At present a significant number of R&D work dealing with use of various Nano materials like Nano silica (NS), Nano-Al_2O_3, Nano-TiO_2, Nano-ZnO, Nano-Fe_2O_3, Nano cement(NC), Nano silica fume (NSF), Nano-flyash (NFA) in cement based materials are available in this literature. The main thing is that the pozzolanic activity of the material is important in forming the C-S-H gel so that size and amount of CH crystals are significantly decreased and the early age strength of hardened cement paste is increased.

K.V.Priya, D.Vinutha[5] investigated the effect of Nano silica (NS) in improving the properties of Rice husk Ash (RHA) concrete and 0.5%, 0.75%, 1% NS is incorporated into 20% RHA concrete for the study. The workability of fresh concrete remains almost the same for normal as well as NS + RHA concrete and also 1% NS into 20% RHA concrete caused an increase in compressive and flexure strength. The disadvantages of rice husk ash had overcome by adding NS particles up to maximum limit of 1% with the average particle size of 10mm.

S. W. M. Supit, F. U. A. Shaikh[9] conducted study on durability of ordinary concrete and high volume fly ash (HVFA) concrete containing NS. For the study concretes containing 2 and 4 %of NS are prepared at a constant water/binder ratio of 0.4 for testing ages of 3, 7, 28, 56 and 90 days. Concrete containing 2 % NS exhibited similar compressive strength of that containing 4 % NS and is used to evaluate its effectiveness in HVFA concrete. The addition of 2 % NS significantly reduced the water sorptivity, volume of permeable voids, chloride permeability and porosity of HVFA concretes. It has been concluded that the above durability properties of concretes containing 38 % class F fly ash and 2 % NS as partial replacement of cement are superior than ordinary concrete containing 100 % cement.

T. K. Behfarnia, A. Keivan and A. Keivan[10] analysed the effects of Nano-TiO2 and Nano-ZnO on the physical and mechanical properties of normal concrete. From the study it is said that both Nano-TiO_2 and Nano-ZnO particles decrease the final compressive strength of concrete. It is because of the negative impacts of this nanoparticles on C_2S hydration which contributes to long-term properties of hydrated cement. And increasing the percentage of Nano-ZnO in the cement mixture completely stopped the hydration process. Permeability test results shows that existence of less than 4wt% of Nano-TiO_2 in the concrete mixture improves the pore structure of the concrete and the lowest coefficient of permeability is achieved. Permeability test results of the Nano-ZnO shows that incorporation of this Nano Materials in the concrete mixture lead to a highly permeable cement paste. Increasing the percentage of Nano-ZnO particles in concrete mixture upto

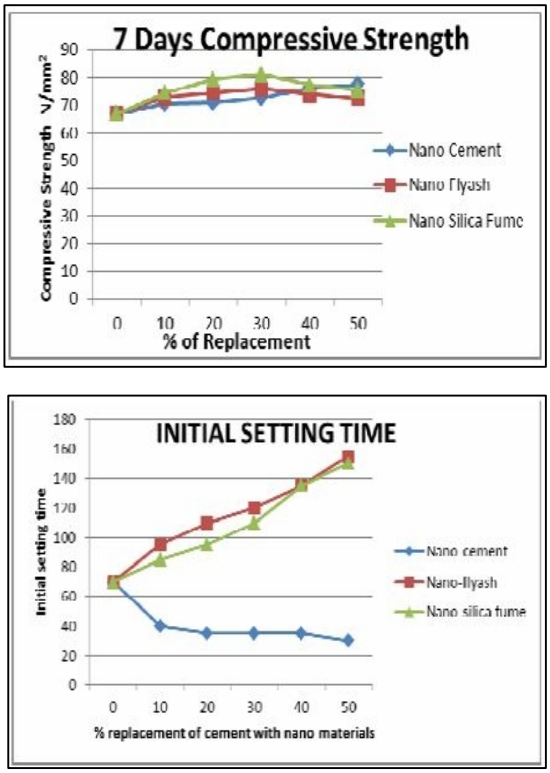

Figure 1 Compressive strength and setting time

4wt% and more thoroughly inhibited the hydration reactions within the concrete.

Jemimah Carmichael.M, Prince Arulraj.G[3] conducted study to understand the influence of Nano Materials on the consistency, setting time and strength of cement mortar in that Cement was replaced with Nano-cement (NC), Nano-flyash (NFA) and Nano-silica fume (NSF). It is found that the consistency is not affected due to the presence of Nano Materials. Figure 1 represent the graph of initial setting time and 7 day compressive strength and that are influenced by the presence of Nano Materials to a greater extent. The result shows that addition of Nano-cement decreases the initial and final setting time of the cement mortar whereas addition of NFA and NSF increases the initial and final setting time.

A. H. Shekaria, M. S. Razzaghib[1] investigated the effect of Nano Materials like Nano-ZrO_2, Nano-Fe_2O_4, Nano-TiO_2 and Nano-Al_2O_3 on durability and mechanical properties of high performance concrete. The content of Nano Materials in each of the specimens was 1.5% of the weight of cementitious materials. It is examined that Nano Materials can improve durability and mechanical properties of high performance concrete and effect of Nano-Al_2O_3 on improvement of mechanical properties of high performance concrete was more than the other Nano-Materials.

Saloma, Amrinsyah Nasution, Iswandi Imran and Mikrajuddin Abdullah[8] studied the influence of NS as a partial substitution of cement in concrete. The presence of NS in concrete is intended to accommodate the byproduct of the cement hydration production in the form of free hydroxide calcium and it will react with C_2S and C_2S in the cement and produce CSH that will form a strong and solid bond of gel. The results in Table 1 and Table 2 shows that the addition of NS as cement partial substitute material could improve the compressive strength and modulus of elasticity respectively.

Table 1 Compressive Strength

Concrete mix	Compressive Strength (MPa)			Percentage of increase of compressive strength (%)		
	3 days	7 days	28 days	3 days	7 days	28 days
NS = 0%	42.576	57.41	89.91	0.00	0.00	0.00
NS = 2.5%	44.202	59.63	94.34	3.82	3.87	4.93
NS = 5%	45.846	61.85	99.28	7.68	7.73	10.42
NS = 7.5%	47.441	65.12	108.59	11.43	13.43	20.78
NS = 10%	47.617	67.31	112.02	11.84	17.24	24.59

Table 2 Modulus of Elasticity

Concrete Mix	Modulus of Elasticity (MPa)		Percentage of modulus of elasticity increases (%)	
	7 days	28 days	7 days	28 days
NS = 0%	39701.48	39921.53	0.00	0.00
NS = 2.5%	40837.71	41382.74	2.86	3.66
NS = 5%	41315.98	42318.52	4.07	6.00
NS = 7.5%	42365.23	43612.29	6.71	9.25
NS = 10%	43110.41	44147.65	8.59	10.59

Jonbi , Ivindra Pane1, Binsar Hariandja , Iswandi Imran[4] studied that the SF is proven effective to improve the mechanical properties and durability of concrete. Experimental program was conducted for SF, combined with the locally produced NS. The result in Figure 2, Figure 3 and Figure 4 represents a graph for compressive strength, RCPT, permeability test respectively. From the result it is concluded that combined use of NS with SF can increase the compressive strength and durability.

Prince Arulraj G, Jemimah Carmichael M[7] conducted an experimental investigation on concrete with Nano flyash (NFA). Different grades of cement M20, M30, M40 and M50 were cast with NFA and for that 10%, 20% and 30% of coarse aggregate was replaced with NFA. The workability and compressive strength of concrete with NFA were determined and the results were compared with that of Normal Cement Concrete (NCC). Concrete with NFA was found to be stronger than NCC and the percentage increase in strength of concrete

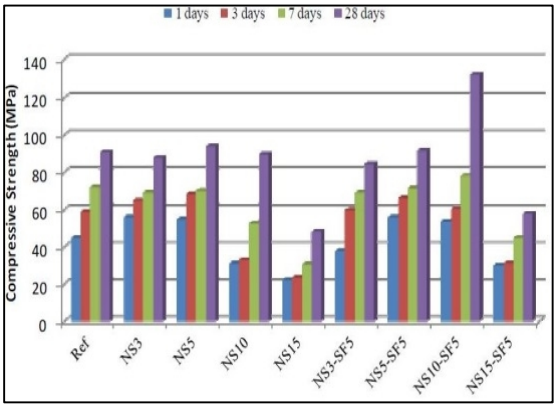

Figure 2 Compressive Strength

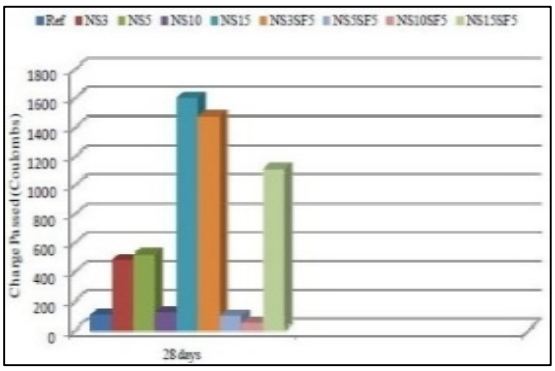

Figure 3 RCPT

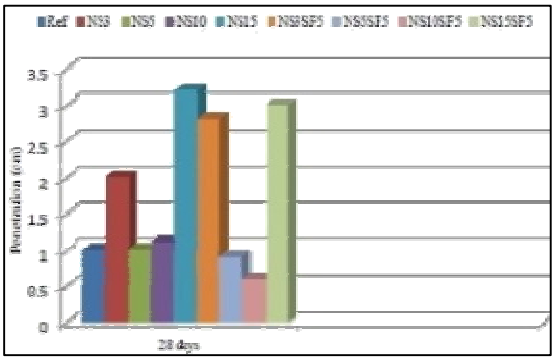

Figure 4 Permeability

with NFA with respect to NCC was found to be in the range 17% to 50% for various grades of concrete. The workability of concrete with NFA was found to be significantly more than that of NCC.

Gengying Li[2] have conducted a laboratory study on the properties of high-volume fly ash high-strength concrete incorporating NS (SHFAC) and compared with those of control Portland cement concrete (PCC) and of high-volume fly ash high-strength concrete (HFAC). It has been concluded that Fly ash has low initial activity but the pozzolanic activity significantly increased after incorporating a little NS. The pozzolanic activity results showed that NS can activate fly ash, and the weight

increment of fly ash incorporating NS at each tested age was higher than that of fly ash plus that of NS. Addition of NS to high-volume high-strength concrete leads to an increase of both short-term strength and long-term strength and also higher porosity at short curing time, while NS acting as an accelerating additive, leads to more compact structures, even at short curing times.

Min-Hong Zhang , Jahidul Islam[6] have conducted experimental study to evaluate the effects of NS on rate of cement hydration, setting time and strength development of concretes with 50% fly ash or slag. Results indicate that rate of cement and slag hydration was accelerated with the incorporation of 1% NS in the cement pastes with high volumes of fly ash or slag. The incorporation of 2% NS by mass of cementitious materials reduced initial and final setting times by 90 and 100 min, and increased 3 and 7 day compressive strengths of high-volume fly ash concrete by 30% and 25%, respectively. NS with mean particle size of 12 nm appears to be more effective in increasing the rate of cement hydration compared with SF, with mean particle size of 150 nm.

4. OUTCOME

The various researches conducted on Nano Materials as an admixture in concrete, the following outcomes measured are as follows:

- Nano cement decreases the initial and final setting time of the cement mortar and addition of NS & NSF increases the initial and final setting time.
- Nano-TiO_2 and Nano-ZnO nanoparticles decrease the final compressive strength of concrete. Increasing the percentage of ZnO nanoparticles in the cement mixture completely stopped the hydration process. And both of these materials decrease the permeability of the concrete.
- Nano-materials can improve durability and mechanical properties of high performance concrete and the contribution of Nano-Al_2O_3 on improvement of mechanical properties of high performance concrete was more than the other Nano Materials.
- The percentage increase in strength of concrete with NF with respect to NCC was found to be in the range 17% to 50 % for various grades of concrete and also workability of concrete with NFA was found to be significantly more than that of NCC.
- The addition of NS as cement partial substitute material can improve the compressive strength and modulus of elasticity of the concrete.
- The incorporation of 2% NS by mass of cementitious materials reduce initial and final setting times by 90 and 100 min, and increased 3 and 7 day compressive strengths.
- Combined use of NS with SF can increase the compressive strength and durability.
- 1% NS into 20% RHA concrete can result in increase in compressive and flexure strength.
- Durability properties of concretes containing 38 % class F fly ash and 2 % NS as partial replacement of cement are superior than ordinary concrete containing 100 % cement.
- The results of pozzolanic activity present that NS can activate fly ash, and the weight increment of fly ash incorporating NS at each tested age was higher. Addition of NS to high-volume high-strength concrete leads to increase of short-term strength and long-term strength.

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