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Effects of Nanoparticles on properties of Self Compacting Concrete (SCC) and Self Compacting Mortar (SCM)

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Abstract*: *Nanotechnology is the most attractive research areas because of its useful applications that have gradually recognized itself in the recent time. Nanoparticles are potential materials in construction industry. Nanoparticles have excellent properties and high surface-to-volume ratio, are known to improve the microstructure of concrete, accelerate the CSH gel formation, and improve the properties of concrete. This study aims to understand the properties of self-compacting concrete (SCC) containing nanoparticles such as nano SiO2, TiO2, ZrO2, CuO. Influence of nano particles to SCC and SCM has received extensive interest from both researchers and construction industry due to their interface improving effect, surface effect and smaller size. This study significantly reviews recent research carried out on the influence of Nano particles on properties of both SCC and SCM. Detailed review on the fresh, strength, microstructural and durability properties of Self Compacting Concrete containing Nano particles are presented. This paper also aims to provide a widespread knowledge insight into possible application of Nanopartices on SCC and SCM in the construction industry.

Keywords: Nanotechnology, nanoparticles, CSH gel formation, modified SCC/SCM

I. INTRODUCTION

Concrete is the widely used building material in the world, its demand increased every year. It has good strength, high elasticity modules, workability and high plasticity. The main element of concrete, Portland cement, produces around 80% of whole CO2 emissions of cement which turn around 6–7% of global whole CO2 emissions. Self-Compacting Concrete (SCC) is a special type of concrete; it is one of the major improvements in concrete in recent time. It is a high fluid concrete that flow under own-weight to fills all the ends of formwork and is consolidated without need of vibration. The main advantages of SCC offer many benefits to achieve self consolidating, casting, and improve performance.

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It also reduced use of equipment, placement of concrete cost, shortening of the construction time and improved quality control. In SCC, The mortar components play a most significant role in the performance. Moreover, the mortar has the similar concrete properties. Mortar contains all the constituents , excluding the coarse aggregate of SCC. It is also more controllable when compared SCC.

Nanotechnology was first introduced by Richard P. Feynman. Recently, nanotechnology has generated interest in the modification of cementitious materials with nanoparticles. By manipulating the nano structure of concrete, such as with nanoparticles and nanoscale, high performance cement based materials nanoparticles, fibers new multifunctional, that could be develop the pore structure of normal concrete, speed up the CSH gel formation, and improve the strength and durability of concrete.

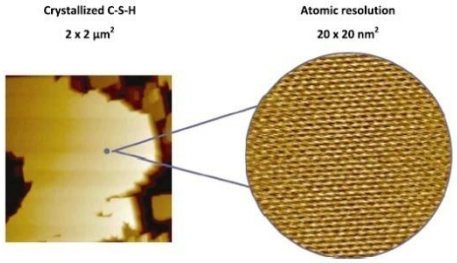

Fig.1 CSH crystallized structure in Nanoscale

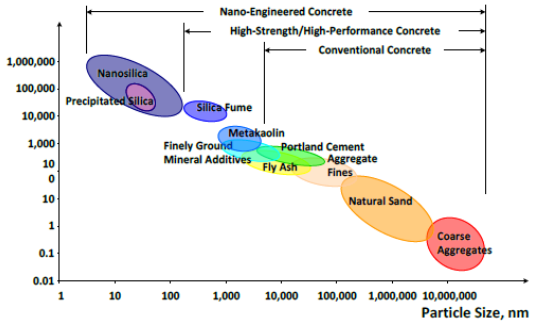

Fig.2 Specific surface area and Particle size of building materials.

This study presents an overview of significant development of nanotechnology with the development of SCC & SCM. In this work, the recent development of SCC and SCM containing nanoparticles such as nano SiO2, TiO2, ZrO2, CuO are reviewed. In this review will highlight the duruabilty, microstructural, fresh and mechanical properties of SCC & SCM.

II. EFFECT OF NANO-SIO2 ON SCC & SCM

A.A. Maghsoudi et al studied the effect of both microsilica, nanosilica on workable and mechanical properties of SCC with various crying condition. The compressive strength was increased about 25, 29 and 33% of SCC containing both nanosilica and microsilica with respectively under wet, dry and sodium sulfate solution curing condition. The shrinkage and swelling amount of SCC mixes decreased with nanosilica.

A.A. Maghsoudi et al experimentally studied that effect of nanosilica on new concrete generation called SCC. The addition of nanosilica in SCC with microsilica causes increase the compressive and flexural strength up to the age of 90days and also pore size in concrete reduced.

Ali Nazari et al observed through tests on strength and thermal properties of SCC containing GGBFS and Nanosilica. Nano silica as a part of replacement of binder content up to 3wt% could improve hydration process, increased nano particles more than 3wt% shows that decrease in strength due to decrease in crystalline $Ca(OH_2)$ needed for formation C-S-H gel. From the conclusions, It has been noted nanosilica could improve the physical and mechanical properties of specimen.

Based on the results of **Rahmat Madandoust et al** , The highest values of slump flow for mixes containing nanosilica seems to have low negative effect on workability of self compacted lightweight concrete with EPS aggregates.

Ali Nazari et al revealed that nano-SiO2 increased upto 4wt% in SCC shows increase in split tensile, flexural and compressive strength. It could act as nanofiller and reduction in permeability of concrete. Macropores and mesopores of concrete have been improved.

Mostafa Jalal et al indicates that consistency of the high performance self compacting concrete is improved by addition of nanosilica and microsilica and reduced bleeding and segregation. Mechanical strength of HPSCC is improved significantly in mixture containing nanosilica could improve hydration process as results of increased Ca (OH_2) crystalline amount early ages. Enhancement was achieved by increasing in binder content. The resistivity results observed that increased at highest ages, especially for the mixures containing nanosilica particiles. According to the SEM micrographs, increased refined microstructure and pore may be reduced by addition of nano-SiO_2.

Morteza H. Beigi et al studied the effects of nanosilica and different concrete reinforcing fibers including steel, glass and polypropylene on the performance of concrete. The results of the study revealed that the presence of both reinforcing fibers and nano-SiO2 in optimal percentages, can improve the fresh, harden and durability of SCC significantly.

Javier Puentes et al experimentally investigated influence of nano silica and carbon nano fiber on SCC, Mechanical properties and at the early age when SCC revolves from a fresh state in to harden structure was assessed. In the mechanical properties of SCC, nano silica improved compressive strength and flexural strength of SCC increased by carbon nano fibers.

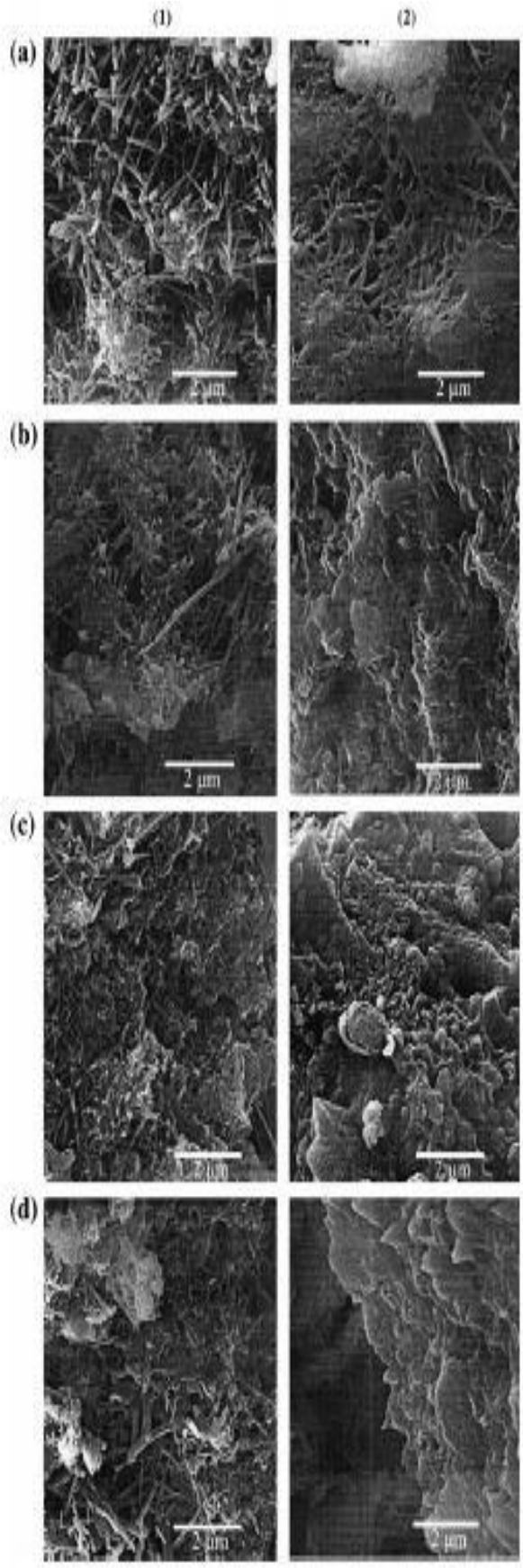

Fig 3. SEM micrographs of HPSCC mixtures

III. EFFECT OF NANO-CuO ON SCC & SCM

Ali Nazari et al studied the effects of Nano CuO on Compressive strength on SCC. Based on the observations Nano CuO particles can able to improve the mechanical strength of SCC and alter the negative effects of superplasticizer. The strength is decreased by increasing PC content. Nano CuO particles can be increased up to 4 wt% replacement of cement, the strength of SCC increased. Microstructure of SCC containing Nano CuO paricles is improved and all macropores and mesopores are decreased.

The split tensile strength of SCC is increased by Increasing Nano CuO up to 4wt%. It is due to more formation of hydrated products presence of Nano CuO. The increase of PC content indicates decrease of the split tensile strength. Based on the thermogravimetric analysis SCC containing Nano CuO particles could decrease the weight of the test specimens when partially added to 4wt% of cement content.

Ali Nazari et al examined the effect CuO Nanoparticles on Properties of Self Compacting Concrete with GGBFS as Binder. Micro of structure of SCC is improved by adding GGBFS up to 45wt%. The flexural strength, compressive strength and split tensile strength is increased by replacement of nano CuO particles up to 3wt%. The pore structure of SCC containing nano CuO particles is improved and the content of all macropores and mesopores is increased. Nano CuO particles develop the resistance to concrete water permeability at 7 and 28 days and curing. It could act as fillers.

Farzad Naseri et al conducted experimental investigation on SCC with polypropylene fibres and nano CuO. Results indicate that Nano-CuO had a significant improvement on compressive strength, flexural strength, electrical resistivity and water absorption of SCC. The partial replacement of binder with a mixture of 0.3% PP fibre and 3% Nano CuO gave better durability and mechanical performances. Nano CuO particles replacement up to 3wt% increased the mechanical strength of Self compacting concrete up to 21%. The addition of polypropylene fibres has no important influence on compressive strength. The use of PP fibre and Nano-CuO enhanced the electrical resistivity of SCC significantly.

IV. EFFECT OF NANO-TIO2 ON SCC & SCM

Ali Nazari et al examined the effect of Nano TiO2 particles on thermal, mechanical and water permeability properties of SCC. The results indicate that the mechanical strength, water permeability of the test specimens are improved by addition nano-TiO2 particles in the cement content up to 4.0 wt%. The pore structure of SCC containing TiO2 nanoparticles is improved.

Based on the results of **Ali Nazari et al,** .the partial replacement of TiO2 nanoparticle of cement 4wt% could accelerate CSH formation and improves the flexural strength. The flexural strength is decreased by increasing PC content. It is due to PC retards hydration of cement especially at early ages. The pore structure of Self Compacting Concrete containing TiO2 nanoparticles is improved and the content of all macropores and mesopores is increased.

V. EFFECT OF NANO-ZNO2 ON SCC & SCM

Nano-ZnO2 particles are improve the mechanical strength of SSC and a partial substitution of binder content up to 4wt% could increase CSH formation. The split tensile strength of SCC increases by decrease PC content. More rapid formation of bogue compounds occurs in the existence of nano-ZnO2 particles can be the reason of more weight loss, which was confirmed by XRD results. Nano-ZnO2 particles up to 4wt% could accelerate the appearance of the first peak in conduction calorimetry (CC) tests which is related to the acceleration of bogue compounds. (**Ali Nazari)**

VI. CONCLUSION

The role and mechanism of the nano particles with various cementitious material and the effects of nanoparticles on the properties of SCM/SCC have been reviewed. Many authors have concluded that addition of nano particles will impart more compact and uniform porestructure inside the concrete. The improvement in strength properties such as split tensile strength, flexural strength and compressive strength of SCM/SCC containing nano particles have been reviewed by several researchers. Use of nano-SiO2 produces dense cement composite materials and incorporation of nano-TiO2, produces photocatalytic concrete. The addition of nanoparticles in SCM/SCC tends to increase in viscosity, cohesiveness, reduction in segregation and bleeding. Finally most of them reported that nanoparticles aids in acceleration of hydration of cement, decrease in permeability and develop the uniform microstructure of SCM/SCC.

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