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Review Paper on Use of Nano Silica and Silica Fume in Concrete

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ABTRACT

Civil Engineering Construction Work now a day's required better Strength in certain conditions properly. Nanotechnology has changed our vision, expectations, and abilities to control the material world. The developments in nano-science will have a great impact on the field of construction materials. Better understanding and engineering of a complex structure of cementbased materials at nano-level will definitely result in a new generation of concrete, stronger and more durable, with desired stress-strain behavior, The current study focuses on using waste materials to partially replace traditional concrete components. Concrete is the most common used material for construction and it consumes almost the total cement production in the world. With the development of HPC, the strength and durability of concrete has improved largely. The improvement of strength and durability properties can be achieved by introducing the silica nano particles as a cementitious material into concrete samples. In addition to that replacement of fine aggregate with new material is becoming popular nowadays and copper slag just being a by product and an industrial waste in copper manufacturing, it can be partially replaced for sand. In this experimental study, workability, mechanical and durability properties of partial replacement of sand with copper slag in nano silica admixed High Performance concrete (HPC) has been investigated

Key words: – **Nanotechnology, Durability, silica nano, silica fume, Pozzolanic**

1. Introduction

Concrete is the material of present as well as future. The wide use of it in structures, from buildings to factories, from bridges to airports, makes it one of the most investigated material of the 21st century. Due to the rapid population explosion and the technology boom to cater to these needs, there is an urgent need to improve the strength and durability of concrete. Out of the various materials used in the production of concrete, cement plays a major role due its size and adhesive property. So, to produce concrete with improved properties, the mechanism of cement hydration has to be studied properly and better substitutes to it have to be suggested. Different materials known as supplementary cementitious materials or SCMs are added to concrete improve its properties. Some of these are fly ash, blast furnace slag, rice husk, silica fumes and even bacteria. Of the various technologies in use, nano-technology looks to be a promising approach in improving the properties of concrete. One of the important and most widely used artificial engineering materials is concrete. It consists of hard inorganic materials called aggregates such as gravel sand crushed stone slag etc cemented together with binding material and water.

Effect of nano silica and silica fume on hardened concrete

Silica fines of nano silica and silica fume are known for their capability to improve the properties of concrete specially strength and durability due to the chemical composition as well as hydration reaction. The silica fines, when added to ordinary Portland cement reacts with calcium hydroxide (CH) leading to formation of calcium silicate hydrates (CSH). In fact, more so it is the low water-cement ratio and the aggregates which control the strength of concrete rather than only the cement paste. Due to the higher strength of concrete containing both types of silica, other properties of concrete also get an impetus. Nano-silica and silica fume enhances the strength, in particular during the first 28 days

2. Literature Review

The study of literature gives us a wider perspective about the work to be carried out. The process of literature review involves the study of the various studies similar to the experiment carried out.

Quercia et al (2003) addressed, the characterization of six different amorphous silica samples with respect to their application in cement paste. Different mixes are compared and analyzed using the mini spread-flow test. Also the granular properties, different void fraction states of packing and distribution moduli q are analyzed and compared using a mix design tool. A deformation coefficient is derived from the spread-flow test, which correlates with the

value of specific surface area computed from the particle size distribution, and intrinsic density of the samples. Finally, the thickness of a constant water layer of 25 nm around the particles is computed at the onset of flowing.

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.

Qing et al. (2005) mentioned the effect of addition of nano silica (NS) on properties of hardened cement paste (HCP) when compared with silica fume (SF) has been calculated through by XRD and SEM analysis. NS increased the viscosity of the cement paste and NS increased the cement hydration process. The results propose that with an addition of little amount of nano silica may be effectively absorbed the CH crystals at the interface between aggregate and hcp at early ages in high performance concrete (HPC).

G,Quercia, H.J.H.Brouwers] A New nS can be produced in high quantities and for low prices allows for a mass application in concrete. It may replace cement in the mix, which is the most costly and environmentally unfriendly component in concrete. The use of nS makes financially more attractive and reduced the CO2 footprint of the produced concrete product. The nS will also increase the product properties of the concrete: the workability and the properties in a hardened state, enabling the development of the high performance of concretes for extreme conditions.

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.

Billa Mahender, B. Ashok] From the compressive strength results, it can be observed that an increase in compressive strength of concrete is observed on the addition of a certain minimum quantity of Nano SiO2. The increase in strength is maximum for nS 1% b.w.c and least for nS 0.3% b.w.c. In addition to 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 by the addition of Nano SiO2 but the overall quality of concrete is preserved. The Nano SiO2 added to the mix filled up the pores in between the C-S-H gel, hence, making the microstructure more compact and uniform.

P. Jaishankar, B. Muthu siva chandru] The influence of nS along with cement concretes supplementary cementitious materials and other cementitious materials. Considerable improvements in the properties of permeability, pore filling effects, microstructure analysis, and strength were reported. As a whole, the entire review showed the ultimatum in using Nanotechnology in general and Nano silica in particular. However, there is a gap or room available for further research towards the fruitful application of Nano silica for construction with different Nanostructure characterization tools, which will be enabled to understand many mysteries of concrete. The compressive strength of concrete had shown an increasing trend with the increase in the quantity of Nano-silica but the increment was stopped when the Nano-silica was beyond 3%. The percentage increase in compressive strength and split tensile strength of concrete with the Nano silica at 3% is 14% more compared to control concrete. The increase in flexural strength is only 2% at 3% Nano-silica partially replacing concrete compared to control concrete. The strength of concrete has drastically decreased by 50% when the Nano-silica is at 4%. It has also been observed that for the combination of 4% Nano-silica the strength is decreased as the dosage might have been crossed the optimum level. Therefore the optimum amount of Nano-Silica partially replacing cement is 3%. Nano-silica in highperformance concrete cause a reduction in pores size and the concrete structures will be more dense and durable.

M.Nill et.al. (2009) studied the combined effect of micro silica and colloidal nano silica on properties of concrete and found that concrete will attain maximum compressive strength when it contains 6% micro silica and 1.5% nano silica. The highest electrical resistivity of concrete was observed at 7.5% micro and nano silica. The capillary absorption rate is lowest for the combination of 3% micro silica and 1.5% nano silica.

Nik et al. (2011) mentioned that the outcomes of the experiment show that the addition of particles of nano-silica enhanced the resistance of water penetration of the concrete and revealed that the admixing of nano-silica particles not only makes cement mortar denser but also altered the morphology of products of cement hydration. The gathered information will then be used for investigating the engineering performance of pervious concrete and observe the effect the nature of surface on the durability of pervious concrete and interrelated to the microstructure of the matrix.

Quercia et al. (2012) explained that in the current years the purpose of nanotechnology has improved exponentially in construction materials. The addition of nano-silica reduces the permeability of hardened concrete as the pozzolanic properties ensuing in more hydrated phases (CSH gel) and densified microstructure. The two types of same particle size distributions nano-silica (produced in two different processes) were used in self-compacting concrete. The effect of nanosilica on SCC was investigated by conducting test of workability and durability. Furthermore, SEM and EDS analysis was performed to check the microstructure of the hardened concrete. The attained outcomes show that the utilization of nano-silica in SCC can enhance durability as well as mechanical properties

Ammar and Mostafa (2012) detailed that nowadays nanotechnology has great effect on numerous areas of science and industry. Nanomaterials can make possible improved use of natural resources and reaching essential materials properties with minimum use. The idea of this study is to investigate the influence of adding nano-silica to cement mortar for improving the durability. The nano silica of three types with three nominal particle sizes have been used with two percentages i.e. 4% and 8% of cement with a w/c ratio of 0.40. The Outcomes reveal adding of nano-silica to cement mortar improves its mechanical properties i.e. permeability and chemical durability.

Jonbi et al. (2012) described material that deserves the awareness of researchers is nanosilica. Silica in the form of silica sand and micro silica has been used as filler and as a reactive pozzolan in concrete respectively. A novel nanotechnological procedure allows manufacture of amorphous nano silica with elevated reactivity from silica sand which is locally available. In this study locally available nano silica instead of commercial nano silica is used on mortar and concrete thus restricting the use of commercial materials. Based on prior research, silica fume is considered efficient to enhance the durability of concrete. In order to get sustainable concrete, the mix is planned for having low permeability with the use of local sources. The results show that joint use of nano silica and silica fume can augment the durability of concrete.

Shanmugasundaram et al. (2013) explained that the experimental tests conducted in relation along with the durability of concrete were presented under the influence of Nano silica in concrete. It is because of the formation of CSH, which forms when silica reacts with CH

Kumar and Sharma (2014) suggested the ways and means emerging the abrasion resistance of concrete prepared with low class aggregates to satisfactory levels on the basis of investigations. The study of grade of concrete, type and quantity of pozzolana, type of aggregate, cement type and age of concrete was done. Different mixes of concrete were planned and cast. Three types of aggregates with three different Los Angeles (L.A.) values were used. A total of 90 cylindrical samples were tested as per procedure laid down in ASTM C 1138 for the assessment of the resistance of abrasion of concrete. The resistance of abrasion of concrete depends upon the properties of aggregates. The resistance of abrasion of concrete degrades significantly once the Los Angeles value of aggregates is more than 30%. Increase in amount of pozzolanic admixtures in concrete mixes improves the resistance of abrasion of ensuing concrete with highest benefits being obtained in silica fume case.

Saloma et al. (2015) mentioned that the green concrete is competent of sustainable growth is characterized by the use of industrial wastes in order to decrease the environmental pollution. Nanomaterial concrete is latest generation concrete which is made of materials of nanoscale grain size. The paper discussed the mechanisms which are used for inclusion of nano materials in concrete improving durability from sulfate attack. Purpose of nanotechnology is an efficient way of dropping environment pollution and enhancing durability of concrete.

C.K. Sridhar, S.B. VanakudreFrom this study, it can be concluded that the optimum replacement of Nano Silica is 2% and 1.5% respectively for M20 & M40 concrete. From the results, it can be concluded that the value of K can be considered as 6.0 to arrive economical mix design. The addition of Nano-particles makes concrete more sticky hence suitable Super-plasticizer can be used to achieve the required workability. Due to the addition of Nano Silica, The percentage increase in M20 concrete is 15.31, 16.3 respectively for 7 days and 28 days whereas in M40 concrete is 11.0, 11.20 respectively for 7 days and 28days

Jonathan S. Belkowitz, Dr. Daniel Armentrout] From the experiments performed, it was validated that as the silica decreases in size and increases in size distribution, several properties begin to improve. Because the silica is on the nanoscale, the crystal development becomes dependent on the availability of reactive silica surface area. When the silica diameter increases, the rate of early pozzolanic reaction decreases. Both nano and micron size silica particles were added at the same concentration. The nano-silica was more effective, due to exposed surface area, in reacting pozzolanically. The micron silica would only react as silica became available. As the CH reacts with exposed micro silica, more silica will become exposed and ready to pozzolanically react. This phenomenon was shown through the early heat signature in the nano-silica mixes.

M. Valipour, A. Mirdamadi A Durability characteristic in form of gas permeability is improved in concrete containing nanosilica. Hence, it can be concluded that the microstructure of the nS is more uniform and compacted than that of concrete containing silica fume. Nano SiO2 pozzolana is more active at an early age than silica fume due to the larger specific surface area and fineness. As shown in compressive strength it seems that nano-silica activation is faster at an early age than SF. But in the long term, both samples have the same strength.

A. Sadrmotazi et.al. (2010), in another paper, have studied the effect of PP fiber along with nano SiO2 particles. The nanosilica was replaced up to 7% which improved the compressive strength of cement mortar by 6.49%. PP fiber amounts beyond 0.3% reduces the compressive strength but beyond 0.3% dose of PP fiber increases the flexural strength, showing the effectiveness of nano SiO2 particles. Also up to 0.5% PP fibers in mortar water absorption decreases which indicates pore refinement.

Mounir Ltifi, Achraf Guefrech The influence of Nano-SiO2 on consistency and setting time are different. Nano-SiO2 makes cement paste thicker and accelerates the cement hydration process. It can be explained by the fact that, in formulations having fixed values of W/B, the presence of Nano-SiO2 decreases the amount of lubricating water available in the mixture. Compressive strengths increase with increasing the Nano-SiO2 content. It seems due to the action of Nano-SiO2 as an activator to promote hydration proves and to improve the microstructure of the cement paste if the nano-particles were uniformly dispersed.

M. Collepardi et.al. (2010) studied the effect of combination of silica fume, fly ash and ultrafine amorphous colloidal silica (UFACS) on concrete. The result shows that steam cured concrete containing SF and FA alone are much stronger than NC cured at room temperature at early age where as compressive strength at 28-90 days of steam cured concrete is less than NC cured at room temperature. So author advised to use SF,FA&UFACS for the manufacturing of precast unit.

3. Conclusion

The review of a number of literatures shows the importance of this field of research. The findings shows that a number of nanomaterials like SiO2, TiO2, Al2O3, colloidal nanosilica, metakaolin and others can be incorporated to improve the properties of concrete. The results show the improved characteristics of the blended concrete in terms of compressive, tensile and flexural strength.

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