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"Application of Silica Fume and Nanosilica in Cement and Concrete – A Review"

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Abstract – This paper reviews the current status of silica fume (micro silica), the application of nano-silica and programs for sustainable development and the recent development of the concrete industry. In addition to this, as well as to conserve energy and resources, to protect the environment and reduce the waste. This contradiction is very limited work on the impact of paste, mortar and concrete, and what the complete use of silica nano-micro silica that can be developed mechanical strength and durability characteristics. It has been studied to understand the impact of micro-and nano-silica in a variety of literature paste, fresh and enhance the fine characteristics of the cement mortar and concrete. It utilizes a nano-structure and microstructure characterization tools and materials, micro-silica nano-silica is a separate optimum use of the time to create a new concrete mixture that occurs in concrete, long-lasting in the future.

I. INTRODUCTION

In the conventional sense, the cement is hardening the binder, as well as independently of the other material in combination with the setting. Cement mortar compound is a building made by mixing the selection of the cementing material with the fine aggregate, and water in a specific amount. Mortar have been used for centuries as a means for attachment to each other bricks or concrete blocks. Cement mortar is still used in the construction of various types of binder between the terrace and the rapid repair of slabs of stone or brick had to reset the pool or the promenade retaining wall, these walls, fences and brick walkway. Unfortunately, the construction industry, as well as well as one of the largest consumers of energy resources and a great responsibility to emissions of greenhouse gases (GHG) such as carbon dioxide responsible for global warming. It's one tons of Portland cement clinker production 1 tons of greenhouse gas is estimated that. Also, due to the accumulation of natural aggregate quarry extraction; It poses an immediate concern for sustainable building development.

1.1 Concrete and Sustainability

Concrete is probably unique in construction, it is the only material exclusive to the business and therefore is the beneficiary of a fair proportion of the research and development money from industry. Concrete is a composite construction material composed primarily of aggregate, cement, and water, which is a nano-structured, complex, multi-phase material that ages over time.

Sustainability without compromising the function of the next generation to meet his needs, and is defined by the World Environmental Development Board as a phenomenon that meet the current needs. It is a good idea to focus on sustainable growth and human development earth welfare by default. Current construction practices are based on long after the rotation as a result of a lack of resources, building materials and large amounts of drinking water consumption.

As well as the sustainable development of the cement mortar, as well as to conserve natural resources and energy to protect the environment and reduce waste. This mortar workability properties of the fresh state is controlled by the properties of the cured state, such as strength and durability, such as particle size distribution, it is influenced by the particle packing resulting graded mix. Rheological properties of the new cement paste has an important role in determining the workability of the concrete. Details of water required for the flow, hydration behavior and properties of the curing conditions will vary depending on the degree of dispersion of the cement in most of the water. Factors in the cement paste of the water content, the initial hydration and water reducing admixtures and mineral admixtures such as silica fume to determine the degree of aggregation.

1.2 Nanotechnology in Concrete

Nanotechnology is rapidly becoming the Industrial Revolution of 21st century (Siegel et al., 1999). It will affect almost every aspect of one's life (IWGN, 1999). In comparison to other technologies, nanotechnology is much less well-defined and well-structured. It is known that 'Nano' is a Greek word and means 'dwarf'. It does not mean dealing with dwarfs but it became a common word for everything which is smaller than 1 Micron or 1 million of a millimeter. 1 Micron is 1000 Nanometer. The nanoscience and nano-engineering (nano- modification) of concrete are terms that have come into common usage and describe two main approaches of applications of nanotechnology in concrete (Scrivener and Kirkpatrick, 2008; Scrivener, 2009).

Until today, concrete has primarily been seen as a structural material. Nanotechnology is helping to make it a multipurpose ''smart'' functional material. Concrete can be nano-engineered by the incorporation of nano-sized building blocks or objects e.g., nanoparticles, nano admixtures and nanotubes) to control material behavior and add trailblazing properties, or by the grafting of molecules onto the cement particles, cement phases, aggregates, and additives (including nano-sized additives) to provide the surface functionality adjusted to promote the specific interfacial interactions of the molecules. Recently, nanotechnology is being used in many applications and it has received increasing attention also in building materials, with potential advantages and drawbacks being underlined (Campillo et al., 2003; Pacheco-Torgal and Jalali, 2011).

1.3 Silica fume

Silica is a common name for a material made of silicon dioxide (SiO2), it occurs in crystalline and amorphous forms. Silica fume or micro silica (SF) is a by-product of the refining process from silicon and ferrosilicon industries. American Concrete Institute defines the silica fume as "elemental silicon or amorphous fine silica produced in an electric furnace to manufacture a by-product of an alloy containing silicon" (ACI Committee 226, 1987b). It is a powder of gray color similar to Portland cement or fly ashes. In addition, iron is composed of silicon and silicon nano-sized powder the average acquisition of 150 nm as a by-product of the production of alloy particle size (diameter) of the spherical particles. The main areas of application are as pozzolan materials for high-performance concrete (Prasad et al., 2003).

1.4 Nano-silica

Nano-silica is typically a highly effective pozzolanic materials. It is usually about 1000 times higher than the average cement particle is composed of very fine glass particles smaller. This has proven to be a superior mixture to improve and reduce the permeability of cement strength and durability (Loland 1981; Aitcin, etc., 1981) .. NS is in relation to the other components of the silica and reduce the setting time of cement strength test results (compression, tension) increases (such as Lodi al., 2008). Nano-silica is obtained by crystallization of nano-size silica or by direct synthesis of the silica sol is determined.

II. EFFECT OF ADDITION OF SILICA FUME NANOSILICA

This silica fume is significantly effective in improving the mechanical properties, and has been recognized as a pozzolan cement admixture. Results in a reduction in the amount of pozzolanic reaction concrete calcium hydroxide, and silica fume is to reduce the porosity, thereby improving the durability. In addition, its activity is inversely proportional to the size, and facilitates the dissolution of the C-S-H to form C-S, and also provide a nucleation site for the C-S-H. Responsible for the further increase of the strength and chemical resistance, and reduction of the absorption rate (DIAB et al., 2012). As well as a micro-cement paste added effect the degradation rates of nano-silica particles to reduce the effect of sound. Is a very small added (0.5 wt.% Binder) is very effective in terms of improving the mechanical properties of the cement-based material of the particles. This is especially pronounced for the regular grade and strength of concrete at early age. Thus, with the SF NS application it can be a successful way for the improvement of the low strength of the cement-based material. Further economic advantage is the low water content and a high durability when used is expected. When prepared using the silica nano NS () mortar with silica fume (SF) is a low water content, the resulting material has a poor operability for most applications. In this case, it is carried out by the addition of an additional amount of water, but the cured state properties of the mineral additional advantage is to be minimized. The use of a plasticizer and a first moving image (SP) is always preferable to improve the rheological properties without the addition of water in addition to (Zheng et al., 2007).

III. LITERATURES REVIEWED

The fundamental processes that govern the most pertinent issues to the study of concrete technology (strength, ductility, early age rheology, creep, shrinkage, durability, fracture behavior, etc) are affected (dominatingly or not), by the performance of the material at the nanoscale. The use of supplementary cementing materials have become an essential part of the Portland cement concrete production, and the research on new materials with supplementary cementing potential is receiving considerable attention from the scientific point of view.

3.1 Influence on Fresh and Mechanical properties

Experiments using nanosilica and silica fume were conducted and the results showed that with 5% replacement of cement by nS (mean size 15±5 nm), 7 & 28-days compressive strength of mortars were increased by 20% and 17%, respectively, whereas 15% silica fume replacement increased mortar strengths by 7% and 10% compared with those of control Portland cement mortar. With the experimental analysis, it was proved that the compressive and flexural strengths of the cement mortars with nano-silica and with nano-Fe2O3 were both higher than that of the plain cement mortar with the same water to binder ratio (Li et al., 2004).

In a study to evaluate the effect of silica fume on the compressive strength, split tensile strength and modulus of elasticity of low quality coarse aggregate concrete was conducted whose results indicated that the type of coarse aggregate influenced the compressive strength, split tensile strength and modulus of elasticity of both plain and silica fume cement concretes. Incorporation of silica fume enhanced the compressive strength and split tensile strength of all concretes especially that of the low quality limestone aggregates (Abdullah et al., 2004).

In an experiment it was showed that the compressive and tensile strengths increased with silica fume incorporation, and the results indicated that the optimum replacement percentage is not constant but depends on the water-cementitious material ratio of the mix. They also found that compared with split tensile strengths, flexural strengths have exhibited greater improvements (Bhanja and Sengupta, 2005) while in another, it was showed experimentally that the compressive strengths of mortars with nano-SiO2 particles were all higher than those of mortars containing silica fume at 7 and 28 days.

It was investigated that there are effects of size of nS on compressive, flexural and tensile strength of binary blended concrete. It was found that the cement could be advantageously replaced by nS up to maximum limit of 2.0% with average particle sizes of 15 and 80 nm. Although the optimal replacement level of nano-Silica particles for 15 and 80 nm size were gained at 1.0% and 1.5%, respectively (Givi et al., 2010).

Further study the properties of the cement mortar of the nano-SiO2 and in the other experiments. Nano SiO2 of test data thicker cement paste were made to accelerate the cement hydration process. The compressive strength is increased to increase the content of nano-SiO2 (Ltifia al., 2011). Researchers have addressed the effects of nanosilica on the mechanical strength of the rheological behavior and the cement mixture. Significant reduction in the mixing processability added nanosilica Cement (Vera et al., 2012) has generated. It was experimentally investigated the impact of nano-SiO2 in cement paste. It was concluded that the nano-SiO2 appeared to affect the structure of the mechanical properties of low density high strength cement paste even. Additional nanosilica seemed to create two competing mechanisms in terms of the overall chemical mechanical response of the cement paste. While the addition of the nanoparticles tend to only increase the mechanical reaction made the one hand increases the result with all the well-established water / cement ratio of the paste was added to excess water. In this case, despite the increase in demand for a maximum of 0.5% 2% nano cement w / w in water in the fresh state 20 to produced a 25% increase in strength. In a second set of samples, the above-described problem (and Stefanidou Papayianni 2012) it was limited.

Effect of nanosilica on the initial intensity setting of the time and volume slag mortar and concrete are shown reduced to set the amount of the incorporated time the experimental findings Ns and 3, increased the compressive strength of 7 days large slag concrete greatly no reference is compared slag inclusions of silica concrete. The results also showed that the length of the sleep period has shortened, and the speed of slag cement and fly ash is hydrated cement paste or accelerated integration daeryangwa Significance ns 1% of the slag. Incorporation of the mass of cementitious material 2% ns is 90 reduces the initial and final setting time to to 100 minutes, and the reference to 3, the ash concrete fly mass by 30% and 25%, respectively, increase the compressive strength of 7 50% compared to the reference concrete of fly ash (such as chapter., 2012).

The rheological properties of bold in the fresh state carboxyl- the effect of micro-and nano-silica under various dosages of a polyether copolymer type water reducing agent were measured. Data was noted that the SF- the system, the maximum intensity of the other hand, NS- system was in excess of the level of 15% by weight to 1.0% by weight is reached. In addition, to obtain high compressive strength SF- system (Zapata et al., 2013). In another experiment, the addition of nano-silica (NS) determines the binary and terpolymers combination on the compressive strength of cement mortar containing Al2O3 (NA) and the nano-Fe2O3 of (NF) powder and fly ash (FA) of the nano and the results showed that there was an increased compressive strength of the mortar more than another rate of the oxide powder of a single type (Oltulu and Sahin, 2013) at 1.25%.

Thus, it was found that in most of the cases, addition of nano-silica and silica fume enhanced the compressive strength and flexural strength with optimized percentages.

3.2 Influence on Durability properties

Absorbent chloride ion test distribution nano-silica concrete is found to have a permeability resistance than normal concrete. As a result pitcher resistance problem (not 2005) Ns large surface area because of the concrete was usually evidence from studies conducted show that jueotdayi attraction than concrete. Through various experiments carried out, (Senff et al., 2010) it was clear that the maximum is reached with 0.35W / B and the mixture, water absorption and porosity of the mortar 7% ns. Factorial design showed that did not follow the shrinkage and weight loss is unlimited linear regression model showed nS mortar and mortar with a value higher than SF. 20 to 81 has increased 80% contraction in seven days, while increasing 54%. Compared to plain concrete containing a chloride permeability of concrete packed nanoparticles (SiO2 with titanium dioxide), and nano-titanium dioxide PP fibers (Berry Li, 2011) containing the concrete containing both polypropylene (PP) fibers and concrete. Test results showed that the addition of nano-particles to purify the pores of the concrete and enhance the resistance to chloride penetration. concrete. NS additional bulk density decreases with increased air content of the mortar. It was studied the water demand of the addition of 1% of the fairy tale, cement W (2012 Stefanidou NAD Papayianni) reduced the increase in strength to change 35% 30% / w; Quercia et a., 2012) addresses the characteristics of the six amorphous silica sample for application of the cement paste. This cement paste without the use of 0.5 to 4.0%, adding the moving image of the nano-silica was determined to be the reduced water demand. Transformation coefficient, and a linear relationship was found between the surface area of the nS / MS particles. High transformation coefficient for the high content of amorphous silica nanoparticles were found larger than the cement (EP). Due to magnesium sulfate attack on proposed guidelines on the compression strength of modified silica fume concrete. This guideline is a known time after the service mix ratio of the concrete mixture used can be used to check the strength of the structural element to be the concentration of magnesium sulfate attack. Application of this guideline shows the risk of using Portland cement and silica fume concrete exposed to magnesium sulfate attack.

3.3 Influence on Microstructural properties

The Scanning Electron Microscope (SEM) observations revealed that the nano-particles were not only acting as filler, but also as an activator to promote hydration and to improve the microstructure of the cement paste if the nano-particles were uniformly dispersed (Li et al., 2004). The results of the experimental analysis indicated that nano-scale SiO2 behaves not only as a filler to improve microstructure, but also as an activator to promote pozzolanic reaction (Qing et al., 2007); Jo et al., 2007).

The X-Ray Diffraction (XRD) showed the presence of CH, already after 9 hours, in samples with nanosilica addition. The nS addition contributed to an increased production of CH at early age compared with samples without nanosilica (Senff et al., 2010). Impressive changes were recorded in the structure of nanomodified samples as the calcium silicate crystal size was larger in samples with high nano-SiO2 content (Stefanidou and Papayianni (2012). This was obvious in pastes with 5% nanoparticles where crystals were formed at 14 days, while at the same age, in pastes with 1% nano-SiO2 the average crystal size was 600 nm. Microstructure observation also recorded a denser structure in nano-modified samples. The results showed that nS can reduce the size of CH crystals at the interface more effectively than SF (Qing et al., 2007).

It was showed that C–S–H gels from pozzolanic reaction of the agglomerates cannot function as binder. The nano-indentation test results revealed that the pozzolanic C–S–H gels from reacted agglomerates showed nearly the same properties as the C–S–H gels from cement hydration (Kong et al., 2012).

The effect of colloidal nano-silica on concrete and significant improvement was observed pertaining to refinement of pore structure and densification of interfacial transition zone. Micro-structural and thermal analyses indicated that the contribution of pozzolanic and filler effects to the pore structure refinement depended on the dosage of nano-silica (Said et al., 2012).

IV. CONCLUSION

Nano technology is the possibility of a new key in the world in the construction and building material sectors. The role and application of nano-materials and cement and micro silica particles and to review and discuss the details. It is clear from the literature review that you did not perform extensive or comprehensive study none of the nano-micro silica and silica coexistence and nature of the paste and the mortar of the researchers. There is limited knowledge of the mechanisms that influence the flow properties of nano-silica micro-silica cement mixtures. In India, the research work on the use of nano-silica is still in elementary school stage. Thus, the widespread need replace only part of such nano various ratios of silica, micro silica and cement occurred to study the various properties of the paste (paste), mortar and concrete, including a combination of the study percentage effect. As related to the properties of nano-silica, micro silica reported in the literature made of or sent from a foreign country, the cement paste, there is a urgent need to study the effects of mortar and on the various properties of the concrete (India Ltd.) these materials. The main parties in the construction materials industry must switch to more funds for research work to integrate nanotechnology in construction materials.

Therefore, the main motive is to provide practical information on the nano-silica, micro silica and paste, mortar and simultaneous strength, sustainability and durability of the characteristics of the concrete. Also, the above object is a general-purpose object to perform pregnancy intensive studies in order to test a new sustainable building process and a modern production system, saving of natural materials and to reduce energy consumption. It utilizes a nano-structure and microstructure characterization tools and materials, micro-silica nano-silica is a separate optimum use of the time to create a new concrete mixture that occurs in concrete, long-lasting in the future. Therefore, a lot of mysteries will be able to understand the different characteristics of the nanostructure of concrete or gap analysis tool, especially in the available room for further fruitful research into the application of nano-silica in construction.

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