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REVIEW ON STRENGTHENING PROPORTIONS OF NANOSILICA AND SILICA FUME IN CONCRETE

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Abstract - *This paper reviews the recent developments and present state of the application of silica fume and nano silica and their suitable proportions for sustainable increase in the strength of concrete. Various works of literatures have been reviewed to understand the influence of nano silica and silica fume on fresh, hardened and micro-structural properties of paste, cement mortar and concrete. Taking advantage of nanostructure and microstructure characterization tools and materials, the simultaneous and also separate optimal use of micro silica and nano silica will create a new concrete mixture that will result in long lasting concrete structures in the future. In this study a locally available nano-silica is used on mortar and concrete thereby limiting the use of commercial nano-silica materials from semi conductor industry waste. To obtain sustainable concrete, the mix is designed to have high strength as well as low permeability using as much possible local sources. This study also shows the strengthening proportions of nano silica and silica fume in concrete. This paper examines the compressive strength of concrete using silica fume and nano silica in the measures of different proportions of cement replacement.*

Keywords: Silica Fume, Nano silica, Compressive strength, Mechanical strength, Strengthening Proportions

1.INTRODUCTION

Nanotechnology has been applied to concrete production and has the potential of improving the performance of concrete. It has been shown to increase the mechanical and durability properties of concrete leading to development of novel and sustainable materials. However, the application of nanotechnology in concrete technology should go along with the availability of local materials. One interesting material to study is nano-silica produced from silica sand. Previous research on concrete using nano-silica has pointed out that improved workability and strength of concrete or mortar are to be expected. The use of nano-silica and silica fume as partial replacement of cement has some advantageous effects on concrete performance. Nano-Silica was also found to be more efficient in enhancing strength than silica fume. Nano-silica can improve the performance of cement-based materials matrix through increased production of CSH gel due to pozzolanic reaction and reduced amount of Ca $(OH)_2$. It can also act as micro and nana filler. 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 nano-tubes to control material behaviour and add trailblazing properties, or by the grafting of molecules onto the cement particles.

1.1Silica-fume

Silica fume is a secondary product manufactured by the smelting process in the silicon and ferrosilicon industry. It is a grey coloured powder, similar to the Portland cement or fly ashes. The ultra-fine particles of silica fume are spherical in nature, having diameter less than 0.001mm. Since it contains high silica content and because of its utmost fineness, it acts a pozzolanic.

Fig 1.1: Silica Fume

1.2.Nano-Silica

Nano-silica appears in the form of white powder or in solution form. It is highly pozzolanic material and is strengthening filler for concrete thus acting as nano filler.

It consists of very fine glassy particles, whitish yellow in appearance. The particles of nano silica are approximately 1000 times smaller than the average cement particles. Nano-silica is obtained by direct merging of silica solution or is obtained by crystallization of nano-sized crystals of quartz. Nano-Silica is a effective pozzolanic material in the form of water emulsion of colloidal silica. The particles of nano silica are spherical in nature and are having size ranging between 7-40nm. It appears to be potentially better than micro-silica because of higher content of amorphous silica (>99%) and the reduced size of its spherical particles.

Fig 1.2: Nano-silica

2. LITERATURE REVIEWS

Much of a literature has presented in the form of technical papers till date on the use of industrial waste in concrete. Some of those are analysed below

J.Bernal, E Rayes, J.Massana, N leon, E sanchez (2018). "Fresh and Mechanical Behaviour of a self compacting concrete with additions of nano silica, silica fume and ternary mixtures".

This paper examines the behaviour of 10 mixtures of SSC prepared with binary and ternary dosages through use of Portland cement, mSi and nSi. A self compacting concrete was designed which used no mineral admixtures, with the rest of the dosages using different percentages.

Mojtaba Fathi, Abed Yousefipour, Ehsan Hematpoury Fakheri (2017). "Mechanical and physical properties of expanded polystyrene structural concretes containing Micro silica and Nano-Silica"

In the specimens without EPS beads, replacement of Micro Silica and Nano Silica upto 15 and 3 wt % of cement respectively led to compressive strength increase and water absorption decrease and after that these trends were carried vice versa.

Ehasan Ghafari et.al (2014) "Effect of nano-silica addition on flowability, strength and transport properties of ultra-high performance concrete" Ehasan Ghafari et.al studied the effect of nano-silica addition on flowability, strength and transport properties of ultra-high performance concrete. They concluded that compressive strength of ultra high performance concrete increases with the rise in nano-silica content. The ultra-high performance concrete containing nano-silica is significantly denser and more homogeneous.

Peng-ku Hou et.al (2012) "Effect of colloidal nano-silica on rheological and mechanical properties of fly ash cement mortar" Peng-ku Hou et.al presented study on effect of colloidal nano-silica on rheological and mechanical properties of fly ash-cement mortar. They found that the addition of colloidal nano-silica enhances hardening process of fly ash cement paste. It also increases the viscosity of cement paste. The compressive strength of fly ash cement mortars can be greatly improved.

Anwar M. Mohamed et.al (2014) "Influence of nano materials on flexural behaviour and compressive strength of concrete" Anwar M. Mohamed et.al presented study on Influence of nano materials o flexural behaviour and compressive strength of concrete. Nano-silica on wet condition and nano clay on dry condition have remarkable improvement on compressive strength of high performance concrete. There also appears improvement for flexural strength of concrete due to use of nano particles.

Min-Hong Zhang et.al (2011) "Use of nano-silica to reduce setting time and increase early strength of concretes with high volume of fly as or slag"Min-Hong Zhang et.al presented study on Use of nano-silica to reduce setting time and increase early strength of concretes with high volume of fly as or slag. The results indicate that length of dormant period was shortened and rate of cement sand slag accelerated with 1 percent nano-silica. The nano-silica reduces the setting time and increases the early strength of high volume fly ash or slag.

Miguel Angel et.al (2015) "Effect of silica fume fineness on the improvement of Portland cement strength-performance" Miguel Angel et.al presented study on effect of silica fume fineness on the improvement of Portland cement strength performance. The partial replacement of Portland cement with 25 percent of silica fume produces high strength mortar and such fineness gives high strength and it can be used to produce high performance concrete.

S.T. Lee, Mr. H.Y. Moon and Mr. R.N. Swamys (2003) "Sulphate attack and role of silica fume in resisting strength loss"

This paper presented study on sulphate attack and role of silica fume in resisting strength loss. This study presents a detailed study on the process of deterioration and the formation of reactants by chemical reaction of mortars and pastes without or with SF in sodium and magnesium sulphate solutions.

Vimal jyothi (2017) Volume 4 "An experimental Investigation on strength properties of concrete containing Micro silica and nano silica" This paper conducts the experiment by replacing the cement by mixture of nano silica and silica fume at different percentages. The compressive strength, flexural strength and tensile strength is increases when the percentage of nano silica at 1.5% and percentage of micro silica at 10%.

3. CONCLUSIONS

According to literature reviews it is concluded that, the compressive strength of concrete increases with partial replacement of the cement in concrete with Nano-silica upto certain limit and decrease with the silica fume if added more then 30% of cement replacement. The influence of Nano-silica along with cement has shown considerable improvement in the properties of permeability, poor filling effect, reduction of C-H leaching, pozzolanic reactions and workability.

4. Scope of the project

Taking advantage of nanostructure characterization tools and materials, the optimal use of nano-silica and silica fume will create a new concrete mixture that will result in long lasting concrete structures in the future. Researchers are capitalizing on nanotechnology to innovate a new generation of concrete materials that overcome the above drawbacks and trying to achieve the sustainable concrete structures. The use of nano-silica and silica-fume makes concrete financially more attractive and reduces the CO_2 footprint of the produced concrete products.

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