Partial Replacement of Cement With Nanosilica To Micro Structural Investigation For Strength Properties Of Cement Mortar- A Review

Vikram Singh¹, Magandeep Bishnoi²
M.Tech Scholar¹, Assistant Professor² Department of Civil Engineering OITM Hisar (125001), Haryana, India
Singh.vikram2031@gmail.com, Er.magandeep8615@gmail.com

Abstract- Nanomaterials than the traditional methods which have been used by researchers to improve the dependability and utility and to reduce the consumption of energy in structures. Nanomaterials can assist in intensifying the use of natural resources and get the required properties by reducing the use of resources. Nanosilica is the next big thing in civil engineering for the advancement of Cement structure. The main aim of this investigation is to explore the influence of colloidal silica on the strength properties of cement mortar. The mortar was made by using Ordinary Portland cement because the Portland Pozzolana Cement contains fly ash i.e. silica content in it. The colloidal silica of 30% concentration with four percentages (0.6%, 1.2%, 1.8%, and 2.4% by weight of replacement of cement) and particle size of 20nm was used for the investigation. Fresh Properties, compressive strength and the microstructural analysis of all the mixes was carried out.

INTRODUCTION
In the present era nanotechnology has numerous no of applications in the construction field. Nanomaterials are the materials which have at least one dimension in the range of 1 to 100 nm. Nanotechnology is an outstanding field of research gaining huge interest and is being applied in various areas to fabricate new products which can outperform with their physical and chemical properties. The most wide-ranging material in the world Cement Mortar is a nano structural composite material that improves with time. The totaling of pozzolanic material is a bless for both cement and concrete because there is a tremendous amplification in the effectiveness. Nano Silica, Silica Fume, Fly ash are the pozzolanic materials. The main prerequisite is to augment the gel structure and stabilize it and to improve the mechanical properties of the casted cement mortar. Nanotechnology

Nanotechnology ("nanotech") is the manoeuvring of substance on molecular and supramolecular range. The earliest, pervasive explanation of nanotechnology referred to the scrupulous scientific purpose of specifically manoeuvring atoms and molecules for fabrication of macro range products, also now acknowledged as molecular nanotechnology. Nationwide nanotechnology established a fresh adequate definition which states that nanotechnology is the manoeuvring of the material with one external dimension ranged from 1-100 nm.

Cement (Ordinary Portland Cement)
Any substance which acts as a necessary agent for materials is identified as Cement. Regular cement which is also known as Roman Cement is attained by crushing and burning the stones containing clay, some amount of carbonates of lime and magnesia. About 20 to 40 percent content of stones is present in the Clay. Natural cement looks a lot like hydraulic lime. It has limited use in practice as it is not strong as artificial cement. When a combination of calcareous and argillaceous materials is burned in correct quantity at very high temperature then artificial cement is obtained.

Uses of Cement:
1. Cement grout for masonry effort, pointing, plaster etc.
2. Concrete for placing roofs, floors and building stairs, pillars, beams, lintels and weather sheds etc.
3. Construction of significant manufacturing erection such as tunnels, culverts, deckels, storage reservoirs, bridges, dams, light houses etc.
4. Building of wells, water tanks, roads, tennis courts, telephone cabins, septic tanks, lampposts etc.
5. Creating linkages for pipes, drains etc.

Fine Aggregates
The aggregates most of which pass through 4.75 mm IS sieve are termed as fine aggregates. According to size, the fine aggregate may be described as coarse, medium and fine sands. Depending upon the particle size distribution IS: 383-1970 has divided the fine aggregate into four grading zones (Grade I to IV). The grading zones become progressively finer from grading zone I to IV. In this experimental program, fine aggregate was locally procured and conformed to Indian Standard Specifications IS: 383-1970

Sources of Sand: Sand particles consist of small grains of silica (SiO₂). It is formed by the
decomposition of sand stones due to various effects of weather. There are the natural sources of sand.

**Pit Sand**: This sand is found as deposits in soil and it is obtained by forming pits to a depth of about 1m to 2m from ground level.

**River Sand**: This sand is obtained from beds of rivers. River sand consists of fine rounded grains. Colour of river sand is almost white. As the river sand is usually available in clean condition, it is widely used for all purposes.

**Sea Sand**: This sand is obtained from sea shores. Sea sand consists of rounded grains in light brown colour. Sea sand consists of salts which attract the moisture from the atmosphere and causes dampness, efflorescence and disintegration of work

**Standard Sand**: Standard sand is used to assess the quality of cement, lime, pozzolana and other mineral admixture used in construction industry

**Grading of Sand**: According to the size of grains, sand is classified as fine, coarse and gravelly Sand passing through a screen with clear opening of 1.5875mm is known as fine sand. It is generally used for masonry works. Sand passing through a screen with clear openings of 7.62mm is known as gravelly sand. It is generally used for plastering. Sand passing through a screen with clear opening of 3.175mm is known as coarse sand. It is generally used for masonry work.

**Water**
Generally, water that is suitable for drinking is satisfactory for use in concrete. Water from lakes and streams that contain marine life also usually is suitable. When water is obtained from sources mentioned above, no sampling is necessary. When it is suspected that water may contain sewage, mine water, or wastes from industrial plants or canneries, it should not be used in concrete unless tests indicate that it is satisfactory

**Cement Mortar**
The term mortar is used to indicate a paste prepared by adding required quantity of water to a mixture of binding material like cement or Lime and fine aggregates like sand. The two components of mortar namely the binding material and fine aggregates are sometimes referred to as matrix the durability, quality and strength of mortar will mainly depends on quantity and quality of the matrix. The combined effect of the two components of mortar is that the mass is able to bind the bricks or stones firmly.

**Nano Silica (Colloidal Silica)**
Silicon dioxide nanoparticles, also known as silica nanoparticles or nanosilica, are the basis for a great deal of biomedical research due to their stability, low toxicity and ability to be functionalized with a range of molecules and polymers. Nano-silica particles are divided into P-type and S-type according to their structure. The P-type particles are characterized by numerous nanopores having a pore rate of 0.61 ml/g. The S-type particles have a comparatively smaller surface area. The P-type nano-silica particles exhibit a higher ultraviolet reflectivity when compared to the S-type.

**Nano silica in Construction field**
Cement is the most broadly used building substance but it is very critical to learn the structural fundamentals of concrete which are efficient at nano range to organize the mechanical and chemical characteristics of cement mortar. Cement mortar is a mixture of cement and fine aggregates linked by interfacial transition zone. by the addition of water this paste form a chemical reaction known as hydration of cement to turn rigid in a particular time span and is heterogeneous in character. The key part of the hydration of cement consist of the Calcium Silicate Hydrate known as C-S-H gel, Calcium Hydroxide, Monohydrate, voids, cement particles. So it is very important to do a detailed study on the mechanical properties and rheology of the cement properties.

**Applications**
The following are the chief applications of silica nanoparticles:
- As an additive for rubber and plastics.
- As a strength filler for concrete and other construction composites.
- As a stable, non-toxic platform for biomedical applications such as drug delivery

**LITERATURE REVIEW**

*Sakshi Gupta (2015)* predicted the compressive strength of concrete with partial replacement of cement with nano-silica using triangular membership function. Author said that Nano-silica can add many benefits to the durability cementations materials. The main aim of the study is to optimize the contents and reduce the cost and efforts by predefining suitable range of nano-silica and it can be used to reduce the amount of cement used in the mix. Fuzzy logic was found useful in the prediction of compressive strength of concrete. So, it can be a useful tool for engineers and scientist in construction area without conducting experimental study in very short span of time and little margin for error.

*Ehsan Ghafari et.al. (2015)* studied the effect of nano-silica on the properties of high performance concrete. Thermo gravimetric analysis showed that nano-silica consumes Ca(OH)2 more than the micro silica at the early stages. The addition of nano-silica results in decrease of capillary pores. The addition of nano-silica enhances the interface between the aggregates and the binding paste. The compressive
strength and the transport properties were increased by the addition of nano-silica. 3% was the optimum amount of cement replacement with nano-silica to obtain maximum performance. Authors concluded that compressive strength increased with the incorporation of nano-silica in specially at the early stages.

P. Di Maida et al., (2015) investigated the effect of powdered and colloidal silica on the properties of cement mortar. Powdered nano-silica used was with particle size of 40nm and colloidal silica used was of partial size 20 nm. The powder ns was synthesised using sol gel technique. SEM and XRD showed that the powder NS is amorphous in nature while colloidal is agglomerated in nature. In the study the compressive strength, CSH quantification and chloride diffusion. Approximately 27 and 37% enhancement in the compressive strength was observed using nano-silica while there was only 19 % increase in the compressive strength when powdered silica was used. On the base of hydration of cement the gel cement ratio was determined and it increases with compressive strength.

Ehsan Mohseni et al., (2014) analysed the influence of nano-silica (5-70 nm) on the physical properties of cement. The strength development of Portland cement with nano-silica was studied. From experimental study of cement mortar with nano-silica an increase in flexural and compressive strength was obtained. The addition of nano-silica resulted in overall enhancement of cement mortar. Cement Mortars with 25% of selected nano-silica a 16% increase in compressive strength was shown after 1day, reaching 63.9 MPa and after 28 days the strength was 95.9 MPa.

R. Yu et al., (2014) studied the effect of nano-silica on Ultra-High Performance Fibre Reinforced Concrete with waste bottom ash. The main aim was to develop a design with densely compacted matrix. In the analysis flexural strength, compressive strengths, porosity and workability was studied. From the results the existence of the metallic aluminium particles was revealed and due to the generation of hydrogen macro cracks in the concrete were visible resulting in the reduced mechanical properties of concrete. With the use of nano-silica the negative effect from Waste Bottom Ash.

Pengkun Hou et al., (2014) studied the influence of two different types of nano-silica in self compacting concrete. The two different nano-silica were having same particle size distribution but manufactured from different processes i.e. fumed powder silica and colloidal silica. Both fresh as well as hardened properties were investigated. Also microstructure was studies.

L.P. Singh et al., (2013) presented review on the effects on nano-silica on hydration, refinement of microstructure, fresh properties, strength properties and durability of cement. Authors concluded that dispersion of nano-silica should be studied and adequate dispersion mechanism of nano-silica is required. The optimum percentage for the replacement with nano-silica cannot be fixed as it depends on the type of nano-silica like whether it is colloidal or dry powder and it also rely

L. Senff et al., (2012) investigated cement mortars by adding nano-SiO\(_2\) and nano TiO\(_2\) with 0-3 percent by wt of cement of nano-silica and 0-12 percent by wt of cement of nano TiO\(_2\). Researches also determined the temperature and strength properties at 28 days. A considerable difference in rheological behaviour was validated. The addition of nano particles reduced the open testing time and the values of torque, viscosity and yield stress was increased.

Peng-kun A.M. Said et al., (2012) studied the combined effects of Colloidal nano-silica and fly ash on cement mortars. Nano-silica used was of 10nm size and the class F fly ash was used. Also experiments for the fresh and hardened properties of cement were conducted. Results obtained showed that the colloidal nano-silica decreases the setting time of cement with fly ash.

G. Quercia et al., 2011 compared and analysed six different silica samples with flow test and the thickness of 25nm water layer was computed. It was shown by granular analysis water demand of the cement mortar can be decreased by adding nano-silica. Authors also concluded that the water demand can be reduced by addition of 0.5-4.0% by wt without any super plasticizers. Also research should be done to modify the conventional nano-silica so that it can be used in mass. It was found that Higher deformation coefficients for specimen with nano-silica was bigger than cement.

Meral & Remzi (2011) studied the combined as well as individual effect of three nano particles namely Nano SiO\(_2\), Nano Al\(_2\)O\(_3\) and Nano Fe\(_2\)O\(_3\)on the permeability and compressive strength of cement mixes containing silica fumes. The percentage used was 0.5%, 1.25% and 2.5% by wt of cement respectively. Compressive strength was calculated at 3 days, 7 days, 28 days, 56 days and 180 days.

V. Ershadi et al., (2011) studied the effect of nano-silica on permeability of oil well. As the nano-silica is very fine in nature so it has been used to improve impermeability and physical properties of the hardened material. With the addition of nano-silica with very fine particles in the matrix the permeability was considerably reduced and the compressive strength was increased from 1486 psi to 3801 psi. various percentages were used to study the effect and
the authors concluded that out of all the specimen with 1% nano-silica is the most adequate. 
**Alireza Naji Givi et.al., 2010** studied the size influence of Nano SiO$_2$ on mechanical and chemical properties of binary blended concrete the researchers used basically two types of nano-silica 15 nm and 80 nm. A partial replacement of cement with different percentages of nano-silica by weight was done. Authors concluded that at initial curing the samples with 15nm particles were comparatively harder than that with 80 nm but after 90 days of curing.

**G.Quercia & H.J.H. Brouwers (2010)** studied the application of nano-silica in concrete mixtures. They concentrated on the reduction of cement content in the mixes because the cement is being used in pretty heavy quantity all over the world and the cement emits CO$_2$ due to increased usage CO$_2$ emission is also increased resulting in green house effect. Authors also studied the suitability of the nS in concrete. Although Nano-silica can improve the chemical and physical properties of cement still it is not being used in the manufacturing industry because its production is complex and it comes on a great cost.

**Belkowitz (2009)** investigated the effect on hydration process of cement by adding Nano-silica. Colloidal silica combines with the Calcium Hydroxide to enhance the strength of the cement. The new structure formed is calcium silica hydrate (CSH). Authors concluded that by addition of nano-silica in the cement mortar many properties of cement begin to improve because the silica decreases in size and increase in size distribution.

**Błyszko, Z et.al., (2008)** examined the influence of nano-silica and micro silica on properties like compressive strength, porosity, absorption and weight loss of cement mortars up to 28 days. The percentage varied from 0-7% for nanosilica and 0-20% for silica fumes by weight and w/c ratio (0.35-0.59). Out of these nS with 7% wt showed faster CSH gel formation. In the case of nS the unrestrained shrinkage was increased to 80% at 7 days as compared to silica fumes was at 54% at 28 days. Authors concluded that specimens with 7% nano-silica has better microstructure. The properties were considerably improved. Authors advised to study the specific samples with more restricted interval For 0.35 Water content the porosity and absorption had maximum values for 7% nano-silica.

**CONCLUSION AND FUTURE SCOPE:**
Tests on concrete specimens must be conducted for more practical use of nano-silica. The chemical durability test must be conducted. From literature it is shown that other type of nano materials show better effect than nano-silica so more research should be done on more nano particles.

Further study must be carried out on the adverse effects of nano-silica on human health. Studies must be conducted to check the feasibility of nano-silica in construction in general. Economic evaluation of incorporating nano-silica must be done. Indian standard codes of practice must be introduced for testing materials with nano particles with different particles sizes.

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