EFFECT OF NANOMATERIAL IN CEMENT HYDRATION PROCESS

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ABSTRACT

Nano Technology is one of the areas which is gaining prominence in the field of Civil Engineering. Application of the concepts of nano technology is steadily growing. Materials at nano stage results in new materials which can change the entire property of the composites to which nano materials are added. Literature reveals that nano particles enhance the strength and durability of concrete . Studies on nano particles added cement paste indicate that stronger and durable concrete can be made by adding particles at nano scale to concrete. At present, many investigations are being carried out to understand the hydration of nano sized cement particles and the use of nano-size ingredients such as alumina, fly ash and silica particles for production of concrete. During the present study, an attempt has been made to understand the influence of nano materials on the hydration of cement by conducting consistency, setting time and strength of cement mortar. This report gives a brief introduction about nano technology and its necessity and literature reviews concerned with nano technology and nano materials in concrete. SEM, EDAX, XRD and FTIR analysis were done to study the material properties and its influence in hydration process. Cement was replaced with nano-silica(NS) and nano-silica fume (NSF). It is found that the consistency is not affected due to the presence of nano materials. The setting time and the compressive strength are influenced by the presence of nano materials to a greater extent. It is found that addition of 20% of nano-silica and 30% of nano-silica fume gave the optimum result.

I.INTRODUCTION

The world of materials is rapidly progressing with new and trendiest technologies, and obviously novel applications. Nano technology is among these modern and sophisticated technologies which is creating waves in the modern times. Actually, Nano technology includes the concept of physics and chemistry of materials. It beckons a new field coming to the limelight. So, Nano technology is an interesting but emerging field of study, which is under constant evolution offering a very wide scope of research activity.Nano-technology is an advanced technology, which deals with the synthesis of Nano-particles, processing of the Nano materials and their applications. Normally, if the particle sizes are in the **1-100 nm** ranges, they are generally called Nano-particles

Transition zone represents the region between the particles of coarse aggregate and hardened cement paste. Transition zone is a plane of weakness and has far greater influence on the mechanical behaviour of concrete. Although transition zone is composed of same bulk cement paste, the quality of paste in transition zone is of poor quality. Firstly due to internal bleeding, water accumulate below elongated, flaky and large pieces of

aggregates. This reduces the bond between the paste and the aggregate. The size and concentration of crystalline compounds such as calcium hydroxide and ettringite are larger in the transition zone. This account for the lower strength of transition zone than bulk cement paste in concrete

Bhuvaneshwari.et.al (June 2013) studied the pore filling effect and its pozzolanic activity with cement towards improvement of mechanical properties and durability aspects.The above discussions described that the influence of NS along with cement, cement mortars, concretes, supplementary cementitious materials and other cementitious materials. Considerable improvement in the properties of permeability, pore filling effects, reduction of CH leaching, rheological behaviour of cement pastes, heat of hydration, micro structure analysis, the pozzolanic activity or reactions and workability, strength and durability were reported **Sakshi Gupta.et.al (December 2013)**studied by using 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 future **V.R.Rathi.et.al (February 2014)**. Nano materials paved the path to reduce the cement content in concrete than the conventional mixes while maintaining same strength characteristics, which will lead into the production of 'greener' concrete. **G.Quercia.et.al(June 2010)** present the state of the art of nS application in concrete, focusing on the nS properties to render it suitable to be applicable in concret**.Hosseni.et.al (March 2011)**reported that the cement mortars containing nano-particles had reasonably higher strength, low water absorption and denser ITZ compared to those of the OPC ferrocement mortars. Furthermore, along with increasing the W/CM, the performance of silicanano-particles has been reduced. Besides, using higher S/CM was followed bystrength loss in both categories of mixtures including with and without silica nano-particles.**Ibrahim.S.Khlila.et.al (October 2013)** study was to investigate the influence of adding nano-silica particles, on the properties of fresh and hardened cement mortar through measurementsof workability, compressive and flexure strengths in addition to measuring by SEM analysis. In addition, the scanning electron microscope (SEM) analysis of the microstructures showed that the nano silica filled the cement paste pores, more homogeneity for cement paste and interfacial zone, by reacting with calcium hydroxide crystals forming more calcium silicate hydration.**Hui Li.et.al (August 2004)** studied the recent developments and present state of the application of silica fume (micro-silica) and nano-silica for sustainable development of concrete industry while comparing nanostructures and microstructures nanostructures gives optimal use of micro silica and nano silica which will create a long lasting concrete in future

II. EXPERIMENTAL PROGRAMME

The experimental programme consisted of making normal cement mortar by replacing cement with nano silica and nano silica fume at different proportions. Normal consistency, initial setting time, and final setting time of cement mortar was determined for each proportion . Electron Microscope (SEM),X-Ray diffraction (XRD) and Fourier transforme infrared spectroscopy (FTIR) was used to study the morphology of the nano silica and nano silica fume. Mortar cubes of size 70mm x 70mm x 70mm were cast and tested using the compression testing machine. The tests were carried at a uniform rate of 14N/mm ^{2} /min after the specimen had been centered in the testing machine.

III. MATERIAL

The materials used are the ordinary Portland cement, fine aggregate of specific gravity 2.67 belonging to zone II replacing different proportions of nano silica and nano silica fume were cast. For making concrete nano silica and nano silica fume was scaled down to nano level and was used for the partial replacement of cement in the production of mortar . The nano- silica and nano silica fume is produced in high intensity ball milling. High impact collisions are used to reduce microcrystalline materials down to Nano crystalline structure without chemical change. [11] The Scanning Electron Microscope (SEM) was used to determine the particle size of nano-silica and nano silica fume

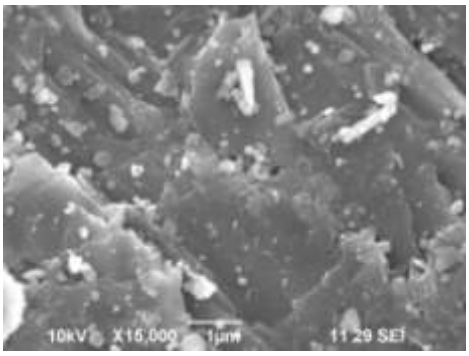

Fig: 1 particle size of nano silica

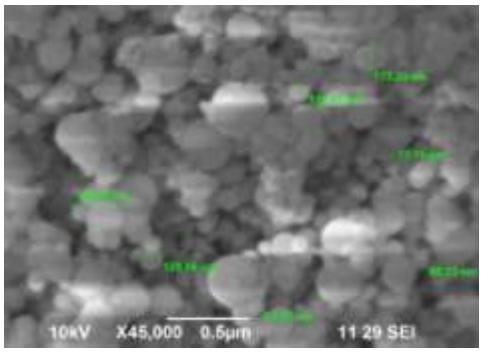

Fig :2 particle size of nano silica fume

From the SEM study it was proved that 80% of the particle have attained the nano size. On 60 hours of ball grinding silica is converted to nano silica and size ranges between Similarly on 3 hours of high energy ball grinding glassy silica fume is converted to nano silica fume and the size range between

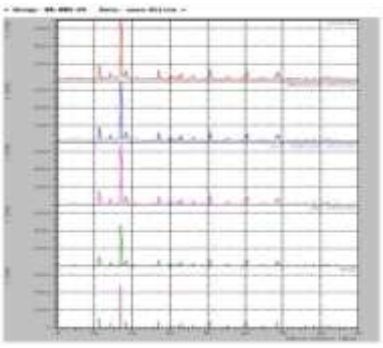

Fig 3 Diffraction graph of nano silica

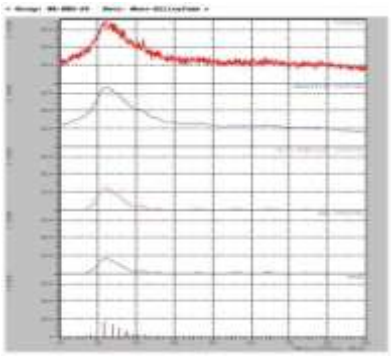

Fig 4 Diffraction graph of nano silica fume

From the XRD analysis done for nano silica fume, silica and nano silica, it was found that nano silica fume reached the range of nano material. Comparing the graphs of silica, nano silica and nano silica fume, in the graph nano silica fume widening of peak value had attain which clearly shows property of nano material .

IV. RESULTS AND DISCUSSION

Normal consistency ,initial setting time and final setting time of cement by replacing with nano silica and nano silica fume are given in table 4 .From table 4 it is clear that the normal consistency is higher when the cement replaced with 30 % nano silica and 20 % nano siloca fume.It can be seen that the presence of nano particles alters the consistency, initial and finial setting time.The compressive strength of the cement mortar when replaced with nano silica and nano silica fume given in table 5

Table: 1 Normal Consistency And Setting Time of Nano Silica and Nano Silica Fume

% Replacement of Nano Particles		Normal Consistency (mm)	Setting Time(mins)	
Nano silica	Nano silica fume		Initial	Final
0	**0**	**34**	70	510
0	50%	33	155	920
10%	40%	34	110	730
20%	30%	34	85	640
30%	20%	35	124	480
40%	10%	33	55	370
50%	0	34	30	245

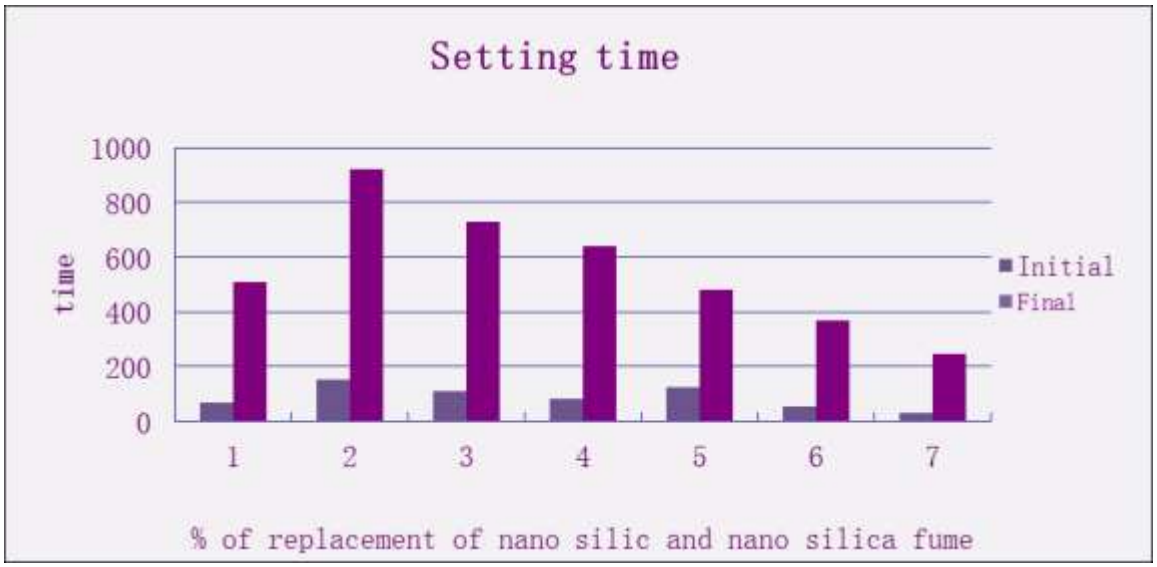

Fig: 5 Setting Time of Cement Replaced With Nano Silica and Nano Silica Fume

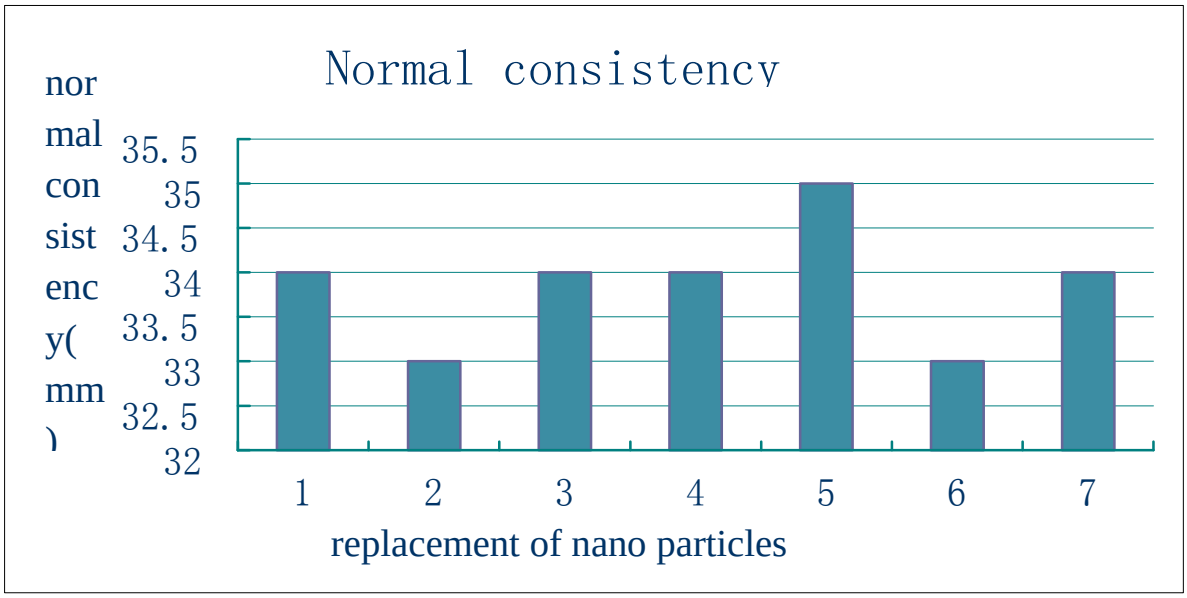

Fig: 6 Normal Consistency of Cement Replaced With Nano Silica and Nano Silica Fume

1. The percentage increase of normal consistency of cement for a replacement of 0% nanosilica and 50% nano-silica fume was found to decrease by 2.94% than whereas initial and final setting time of cement was found to increase by 121.4% and 78.5% than normal cement respectively

2. The percentage increase of normal consistency of cement for a replacement of 10% nanosilica and 40% nano-silica fume was found to be same whereas initial and final setting time of cement was found to increase by 57.14% and 78.43% than normal cement respectively

3. The percentage increase of normal consistency of cement for a replacement of 20% nanosilica and 30% nano-silica fume was found to be same whereas initial and final setting time of cement was found to increase by 21.42% and 25.45% than normal cement respectively

4. The percentage increase of normal consistency of cement for a replacement of 30% nanosilica and 20% nano-silica fume was found to increase by 2.94% whereas initial and final setting time of cement was found to increase by 77.14% and decreased by 5.88% than normal cement respectively

5.The percentage increase of normal consistency of cement for a replacement of 40% nanosilica and 10% nano-silica fume was found to decrease by 2.94% whereas initial and final setting time of cement was found to decresed by 21.42% and 37.83% than normal cement respectively

6.The percentage increase of normal consistency of cement for a replacement of 50% nanosilica and 0% nano-silica fume was found to be same whereas whereas initial and final setting time of cement was found to decreased by 57.14% and 51.96% than normal cement respectively

% Replacement of Nano Particles		**Compressive Strength of nano silica and nano silica fume**		
Nano-silica fume	**Nano-silica**	**3days**	**7days**	**21 days**
0	**0**	52.5	67	73
0	50%	58.24	72.3	80.62
10%	40%	56.99	72.98	80.02
20%	30%	57.98	74.48	82.76
30%	20%	58.98	75.99	83.48
40%	10%	59.98	74	82.48
50%	0	57.5	72.48	79.98

Table: 2 compressive strength of cement replaced with nano silica and nano silica fume

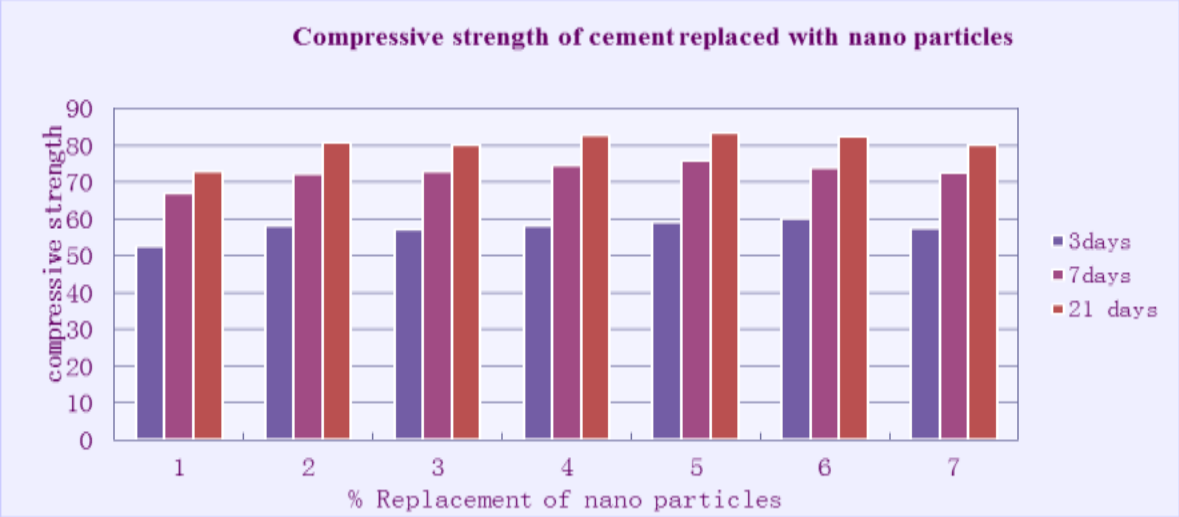

Fig.7 Compressive Strength of Cement Replaced With Nano Silica and Nano Silica Fume

4.1 3 Days Compressive Strength

1. The percentage increase of compressive strength of cement for a replacement of 0% nano-silica and 50% nano-silica fume was found to increase by 10.93% than normal Cement respectively.
2. The percentage increase of compressive strength of cement for a replacement of 10% nano-silica and 40% nano-silica fume was found to increase by 8.55% than normal Cement respectively.
3. The percentage increase of compressive strength of cement for a replacement of 20% nano-silica and 30% nano-silica fume was found to increase by 10.43% than normal Cement respectively.
4. The percentage increase of compressive strength of cement for a replacement of 30% nano-silica and 20% nano-silica fume was found to decrease by 12.34% than normal Cement respectively.

The percentage increase of compressive strength of cement for a replacement of 40% nano-silica and 10% nano-silica fume was found to decrease by 14.24 % than normal Cement respectively.

The percentage increase of compressive strength of cement for a replacement of 50% nano-silica and 0% nano-silica fume was found to decrease by 9.52 % than normal Cement respectively.

4.2 7 Days Compressive Strength

1. The percentage increase of compressive strength of cement for a replacement of 0% nano-silica and 50% nano-silica fume was found to increase by 7.91% than normal Cement respectively.
2. The percentage increase of compressive strength of cement for a replacement of 10% nano-silica and 40% nano-silica fume was found to increase by 8.92% than normal Cement respectively.
3. The percentage increase of compressive strength of cement for a replacement of 20% nano-silica and 30% nano-silica fume was found to increase by 11.14% than normal Cement respectively.
4. The percentage increase of compressive strength of cement for a replacement of 30% nano-silica and 20% nano-silica fume was found to decreased by 13.41% than normal Cement respectively.
5. The percentage increase of compressive strength of cement for a replacement of 40% nano-silica and 10% nano-silica fume was found to decrease by 10.44 % than normal Cement respectively.
6. The percentage increase of compressive strength of cement for a replacement of 50% nano-silica and 0% nano-silica fume was found to decrease by 8.19 % than normal Cement respectively.

4.3 21Days Compressive Strength

1.The percentage increase of compressive strength of cement for a replacement of 0% nano-silica and 50% nano-silica fume was found to increase by 10.43% than normal Cement respectively.

2.The percentage increase of compressive strength of cement for a replacement of 10% nano-silica and 40% nano-silica fume was found to increase by 9.61% than normal Cement respectively.

3.The percentage increase of compressive strength of cement for a replacement of 20% nano-silica and 30% nano-silica fume was found to increase by 13.36% than normal Cement respectively.

4.The percentage increase of compressive strength of cement for a replacement of 30% nano-silica and 20% nano-silica fume was found to decreased by 14.35% than normal Cement respectively.

5. The percentage increase of compressive strength of cement for a replacement of 40% nano-silica and 10% nano-silica fume was found to decrease by 12.98 % than normal Cement respectively.

6.The percentage increase of compressive strength of cement for a replacement of 50% nano-silica and 0% nano-silica fume was found to decreased by 9.56% than normal Cement respectively.

VI. CONCLUSION

- The normal consistency, initial setting time and final setting time behavior of cement paste by replacing cement with Nano-silica and Nano silica fume were carried out
- The compressive strength of cement mortar by replacing cement with Nano silica and Nano silica fume in 3 days 7 days and 21 days carried out
- From the SEM analysis result, it was found that the particles undergone grinding in ball grinding machine attained 70 % to 80 % nano material
- From XRD it was found by comparing nano silica and nano silica fume, had attained wide range of nano material property
- By replacing 50 % cement by 30 % nano silica fume and 20 % nano silica give higher value of normal consistency
- It was found that replacing 50% of cement in the mix by 30 % nano silica fume and 20% of nano silica shown higher initial setting value and final setting value
- On comparing the compressive strength on 3days,7days and 21 days it was found that replacing 50 % cement by 40% nano silica fume and 10 % of nano silica, 30 % of nano silica fume and by 20% of nano silica ,30% of nano silica fume and 20% nano silica shown higher compressive strength on 3 day 7 day and 21 day

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