SYNTHESIS, CHARACTERIZATION AND DEVELOPMENT OF NANOCOMPOSITE

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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 [(1)]. 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 [(3)]. 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 [(4)], fly ash and silica particles for production of concrete. During the present study, an attempt has been made to understand the influence of adding two nano materials on the consistency, setting time and strength of cement mortar. Cement was replaced with nano-cement (NC) and nano-flyash (NFA). 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 nano particles decreases the initial and final setting time of the cement mortar. Also the compressive strength is increased compared to cement mortar without nano materials

Keywords: Nano Technology, Cement Mortar (NCM), Nano-Cement (NC), Nano- Fly Ash (NFA), Consistency, Setting Time, Compressive Strength. .

I INTRODUCTION

Nanotechnology is one of the most active research areas that encompass a number of disciplines including Civil Engineering and construction materials. Currently this technology is being used for the creation of new materials, devices and systems at molecular, nano and micro-level. Nanomaterials show unique physical and chemical properties that can lead to the development of more effective materials than the ones which are currently available. The use of nano-materials can improve the function and properties of many types of elements. Recently, nanotechnology has attracted considerable scientific interest due to the new potential uses of particles in nano scale. The nano-scale particles can result in dramatically improved properties from conventional grain size materials of the same composition.

Application of nano-materials into the production of cement and concrete can lead to significant improvements in the field of Civil engineering since the mechanical strength and life of concrete structures are determined by the micro-structure and by the mass-transfer in nano-scale. Due to the materials very small size, they have some remarkable, and in some cases, novel properties. Significant enhancement of optical, mechanical, electrical, structural and magnetic properties are commonly found with these materials. ***Hasan Biricik et.al.[1]*** conducted a study between nano silica, silica fume, and flyash incorporated cement mortars using Fourier transform infrared spectrometer (FTIR), thermogravimeter-differential thermogravimeter (TG-DTG) and scanning electron microscope (SEM), wherein the mechanical strengths of the specimens were determined at early (7^{th} day) and standard (28^{th} day) curing ages**..** The compressive strengths developed in the mortar specimens containing NS particles was found to be considerably higher than those of the corresponding specimens of SF and FA at early and standard ages. Parallel to the increase in the amount of NS from 5 wt% to 10 wt%, the increases in compressive strength at both ages were observed. ***Yilmaz kocak[2]*** experimentally determined the mutual influence of fly ash and silica fume on Portland cement. Fly-ash and silicafume slowed down hydration speed, decreased hydration heat and temperature and hence were effective against contraction by increasing the setting time. Properties such as compressive strength, modulus of elasticity, free and restrained shrinkage, measurement of internal relative humidity, isothermal calorimetry, and semi-adiabatic temperature rise of cement replaced with class C flyash was evaluated by ***Igor De la Varga et.al [3]***. HVFA mixtures with w/cm of 0.30 had higher strength at later ages (28 d, 91 d, and 365 d) compared to the reference mortar**.** ***K. Thomas Paul et.al***[4] characterized nano structured fly ash for its particle size by using particle size analyzer, specific surface area with the help of BET surface area apparatus, structure by X-ray diffraction studies and FTIR, SEM and TEM was used to study particle aggregation and shape of the particles which revealed that the surface of the nano structured fly ash is more uneven and rough and shape is irregular, as compared to fresh fly ash which are mostly spherical in shape. ***Maile Aiu[5]*** conducted an experiment focusing on synthesizing the components of Portland cement type I using nano-particles and comparing their properties with that of commercial cement. Scanning electron microscopy (SEM) and X-ray diffraction (XRD) tests were conducted to study the morphology and structure of synthesized tricalcium silicate (C3S) components. The results showed conglomerated Nano-particles with crystalline structures containing quantities of tri- and di- calcium silicate compounds as well as copper oxide. Hydration testswere also performed and the results show that the Nano-cement has a more rapid hydration rate than Portland cement. ***V.R.Rath et.al[6]*** reviewed the efforts, current status, and effect of various nano materials on properties of cement mortar and concrete due to its large surface area concluding that nanoparticle addition improves compressive, flexural strength, hydration characteristics and reduced porosity and water absorption. Nano materials can also reduce the cement content in concrete while maintaining same strength characteristics, which will lead into the production of 'greener' concrete. ***Jemimah Carmichael et.al [7]*** investigated the effect of nano-flyash on the strength of concrete. It was found that the 28 day strength of 10% nano-flyash was higher than normal cement concrete.

II EXPERIMENTAL PROGRAMME

In this experimental study cement mortar cubes with and without nano particles was used. A combination of nanofly ash and nanocement with various percentage was used as a replacement of cement. Normal consistency,

setting time and compressive strength tests were done. Scanning Electron Microscope (SEM) was used to study the morphology of the nano fly ash and nano cement.

III MATERIAL

The materials used are the ordinary Portland cement of grade 5 conforming to IS 10269:1982, fine aggregate of specific gravity 2.67 belonging to zone II, nano flyash and nano cement. For making the composite mortar, ordinary Portland cement and class F fly ash was scaled down to nano level with the help of high intensity ball milling. High impact collisions are used to reduce microcrystalline materials down to nano crystalline structure without chemical change. The Scanning Electron Microscope (SEM) was used to determine the particle size of the nano materials. The SEM images of cement, nano-cement, flyash and nano-flyash are shown in figure 1,2,3 and 4 respectively.

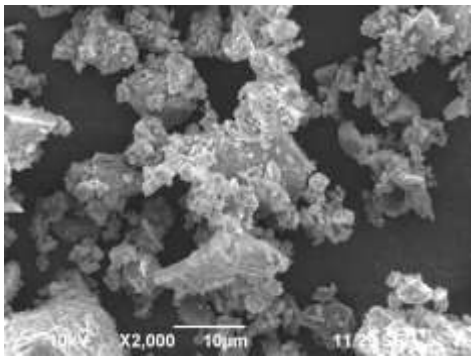


Figure 1: SEM picture of cement

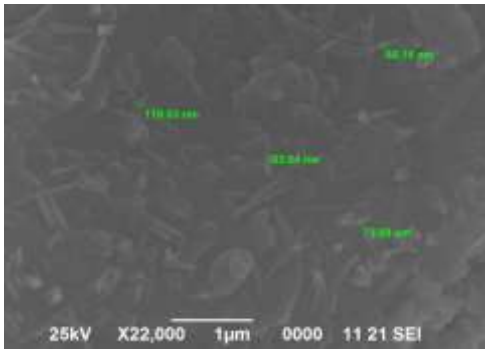


Figure 2: SEM picture of nano cement

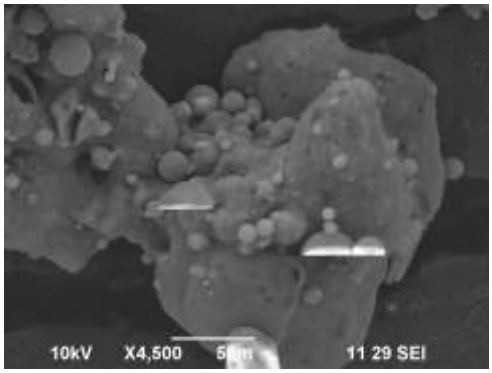


Figure 3: SEM picture of fly ash

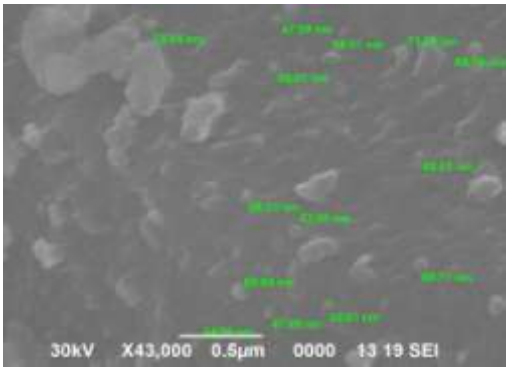


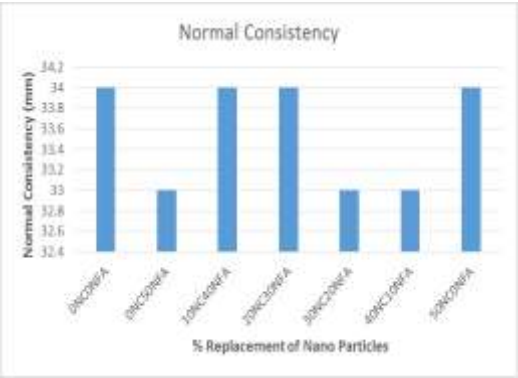
Figure 4: SEM picture of nano flyash

IV RESULTS AND DISCUSSION

The normal consistency, initial setting time, final setting time and compressive strength results are shown in table 1

Table 1: Normal Consistency, Initial Setting Time, Final Setting Time and Compressive Strength

% Replacement of Nano Particles		Normal Consistency (mm)	Setting Time(mins)		Compressive Strength		
Nanocement	Nanoflyash		initial	final	3 days	7days	21 days
0	0	34	70	510	52.5	67	73
0	50%	33	155	920	51.5	64.86	81.75
10%	40%	34	110	730	52.76	65.42	80.02
20%	30%	34	85	640	52.9	68.75	81.78
30%	20%	33	70	530	58.98	73.12	84.64
40%	10%	33	55	370	63.84	74	86.22
50%	0	34	30	245	68	75.53	88



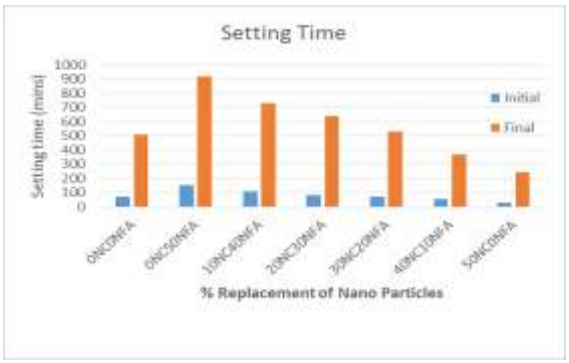


Figure 5:Chart depicting normal consistency **Figure 6: Chart depicting initial and final setting time**

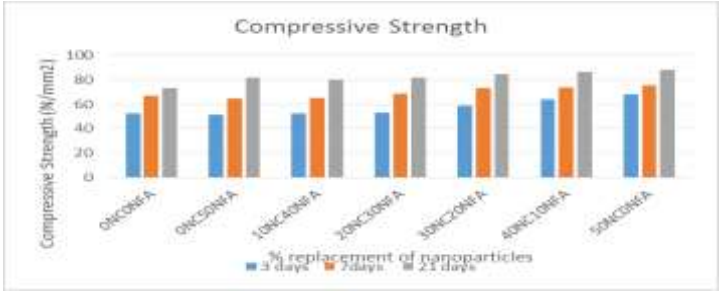


Figure 7: Chart depicting compressive strength

4.1 Discussion of normal consistency, initial setting time and final setting time.

1. The percentage of normal consistency for 0% replacement of Nano-cement and 50% replacement of Nano-flyash was found to decrease by 2.94 % whereas initial setting time and final setting time of cement was found to increase by 121. 4 % and 80.9 % than Normal Cement respectively.

2. The percentage of normal consistency for 10% replacement of Nano-cement and 40% replacement of Nano-flyash was found to be the same whereas initial setting time and final setting time was found to increase by 57.1% and 43.1% that of Normal Cement respectively.

3. The percentage of normal consistency for 20% replacement of Nano-cement and 30% replacement of Nano-flyash was found to be the same whereas initial setting time and final setting time of cement was found to increase by 21. 4 % and 25.4 % that of Normal Cement respectively.

4. The percentage of normal consistency for 30% replacement of Nano-cement and 20% replacement of Nano-flyash was found to decrease by 2.94 % whereas final setting time was found to increase by 3.9% that of Normal Cement respectively. The initial setting time was the same.

5. The percentage of normal consistency of cement for 40% replacement of Nano-cement and 10% replacement of Nano-flyash was found to decrease by 2.94 % whereas the initial setting and final setting time was found to decrease by 21.94 % and 27.4 % than Normal Cement respectively.

6. The percentage of normal consistency of cement for 50% replacement of Nano-cement and 0% replacement of Nano-flyash was found to be the same whereas the initial setting and final setting time was found to decrease by 57.1% and 51.9% that of Normal Cement respectively.

4.2 Compressive Strength

4.2.1 3 days compressive strength

1. The percentage increase of compressive strength of cube for 0% replacement of Nano-cement and 50% replacement of Nano-flyash was found to decrease by 0.961% than Normal Cement mortar for 3 days.
2. The percentage increase of compressive strength of cube for 10% replacement of Nano-cement and 40% replacement of Nano-flyash was found to increase by 1.46% than Normal Cement mortar for 3 days.
3. The percentage increase of compressive strength of cube for 20% replacement of Nano-cement and 30% replacement of Nano-flyash was found to increase by 1.73% than Normal Cement mortar for 3 days.
4. The percentage increase of compressive strength of cube for 30% replacement of Nano-cement and 20% replacement of Nano-flyash was found to increase by 13.42% than Normal Cement mortar for 3 days.

5. The percentage increase of compressive strength of cube for 40% replacement of Nano-cement and 10% replacement of Nano-flyash was found to increase by 22.769% than Normal Cement mortar for 3 days.
6. The percentage increase of compressive strength of cube for 50% replacement of Nano-cement and 0% replacement was found to increase by 0.769% than Normal Cement mortar for 3 days.

4.2.2 7 days compressive strength

1. The percentage increase of compressive strength of cube for 0% replacement of Nano-cement and 50% replacement of Nano-flyash was found to decrease by 3.194% than Normal Cement mortar for 7 days.
2. The percentage increase of compressive strength of cube for 10% replacement of Nano-cement and 40% replacement of Nano-flyash was found to decrease by 2.35% than Normal Cement mortar for 7 days.
3. The percentage increase of compressive strength of cube for 20% replacement of Nano-cement and 30% replacement of Nano-flyash was found to increase by 2.61% than Normal Cement mortar for 7 days.
4. The percentage increase of compressive strength of cube for 30% replacement of Nano-cement and 20% replacement of Nano-flyash was found to increase by 9.13% than Normal Cement mortar for 7 days.
5. The percentage increase of compressive strength of cube for 40% replacement of Nano-cement and 10% replacement of Nano-flyash was found to increase by 10.44% than Normal Cement mortar for 7 days.
6. The percentage increase of compressive strength of cube for 50% replacement of Nano-cement and 0% replacement was found to increase by 12.73% than Normal Cement mortar for 7 days.

4.2.3 21 days compressive strength

1. The percentage increase of compressive strength of cube for 0% replacement of Nano-cement and 50% replacement of Nano-flyash was found to increase by 11.194% than Normal Cement mortar for 21 days.
2. The percentage increase of compressive strength of cube for 10% replacement of Nano-cement and 40% replacement of Nano-flyash was found to increase by 9.61% than Normal Cement mortar for 21 days.
3. The percentage increase of compressive strength of cube for 20% replacement of Nano-cement and 30% replacement of Nano-flyash was found to increase by 12.61% than Normal Cement mortar for 21 days.
4. The percentage increase of compressive strength of cube for 30% replacement of Nano-cement and 20% replacement of Nano-flyash was found to increase by 15.13% than Normal Cement mortar for 21 days.

5. The percentage increase of compressive strength of cube for 40% replacement of Nano-cement and 10% replacement of Nano-flyash was found to increase by 18.44% than Normal Cement mortar for 21 days.

6. The percentage increase of compressive strength of cube for 50% replacement of Nano-cement and 0% replacement was found to increase by 20.73% than Normal Cement mortar for 21 days.

V CONCLUSION

An experimental investigation has been carried at to find out at the effect of replacing cement with nano-cement and nano-flyash on the strength, consistency, initial and final setting times of cement mortar. It was found that replacement of nano materials had insignificant effect on the consistency of cement paste. The initial and final setting times of cement mortar containing nano-cement was found to decrease with addition of nano-flyash increase in the replacement percentage. The strength varies between 1-20% compared to cement mortar without nano particles.

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