INFLUENCE OF NANO FLYASH ON FLEXURAL STRENGTH OF CONCRETE

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ABSTRACT

Nano science and technology is a new field of emergence in materials science and engineering, which forms the basis for evolution of novel technological materials. Nano technology finds application in various fields of science and technology. This article presents the influence of nano-materials on the mechanical strength of in concrete and its application for the development of sustainable materials in the construction industry. An attempt has been made to study the compressive strength, split tensile strength and flexural strength of concrete with partial replacement of fine aggregate with nano-fly ash, nano-silica and nano- silica fume towards improvement of its mechanical properties. Different grades of concrete viz., M20, M30. M40 and M50 were cast with nano materials. For each grade of concrete, 0%, 10%, 20%, 30%, 40% and 50% of fine aggregate was replaced with nano materials. Nanomaterials are obtained by grinding the micro sized materials in ball grinding machine and the particle size is determined by using Scanning Electron microscope. The compressive, split and flexural strength of concrete with nano-fly ash, nano-silica and nano- silica fume were determined and the results were compared with that of conventional concrete(NCC).Micro sized silica and silica fume are made in to nano size by grinding them in high energy ball grinding machine. A scanning electron microscope was used to determine the particle size of the nano- silica and nano- silica fume . Comparative study was done on cement mortar and cement mortar with nano silica and nano- silica fume. The workability of concrete with nano materials was found to be significantly more than more than that of Conventional Cement Concrete (NCC). The 28th, 56th and 90th day strength and durability characteristics were compared for the NCC and concrete with nano materials. Concrete with nano materials was found to have more strength and better durability than that of NCC. Concrete with replacement of 30% nano-silica and 40% nano-silica fume perform better.

Keywords: Compressive Strength, Split Tensile Strength, Flexural Strength, Nano-Fly Ash, Nano-Silica, Nano-Silica Fume.

I. INTRODUCTION

Nanotechnology is the use of very small particles of size 10^{-9}m called as Nano-particles. The structure is studied using the various techniques such as Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM) and, X-ray diffracted (XRD). Virtually every aspect of the construction process will be touched by the foregoing innovations of nano-scale technologies. The nano scale-size of particles can result in dramatically improved properties from conventional grain-size materials of the same chemical composition. Nano-materials show unique physical and chemical properties that can lead to the development of more effective materials than the ones which are currently available. The extremely fine size of nano-particles yields favorable characteristics. Moreover, the rapid development of the field of materials science on the nano-scale has offered the civil engineers a new window of understanding into traditional construction materials, such as cementitious materials or steel, allowing us to enhance their properties, extend their lifetime bringing cost-savings and reduction in energy consumption.

II. LITERATURE REVIEW

Hasan Biricik et.al.[1] conducted a study between nano silica(NS), silica fume(SF), and flyash(FA) incorporated cement mortars using Fourier transform infrared spectrometer (FTIR), thermogravimeter-differential thermogravimeter (TG-DTG) and scanning electron microscope (SEM). The mechanical strengths of the specimens were determined at 7th day and 28th day. The compressive strengths and flexural strengths NS was found to be higher than SF and FA. Three types of nanoparticles such as nano-clay, nano-$CaCO_3$, and nano-SiO_2 were used in the compressive strength studies done by *Shiho Kawashima*[2]. The study shows that nno-SiO_2gives a higher vlues than other nano particles *Yilmaz kocak*[3] experimentally determined the mutual influence of fly ash and silica fume on Portland cement. 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* [4].A comparision study on between the effect of limestone powder (LP) on the properties of SCRM and other mineral additives (silica fume (SF) and fly ash (FA) and their combinations) effects was done by *Selcuk Turkel et.al* [5].*K. Thomas Paul et.al*[6] characterised 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. *Maile Aiu*[7] 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 properties of the fracture surfaces of hydrated Portland cement pastes were investigated by *Tomaš Ficker*[8]. *P.J.M.Monteiro et.al*[9] characterized the nano and microstructure of cement paste and concrete exposed to aggressive environments. Sakshi Gupta[10] studied the recent developments and present state of the application of silica fume (micro-silica) and nano-silica for sustainable development of concrete industry. On comparing nanostructures and microstructures, nano structures gives optimal use of micro silica and nano silica which will create a long lasting concrete in future. Hui-gang Xiao[11] carried out experimental investigation on the mechanical properties of cement mortar with nano-Fe_2O_3 and nano-SiO_2. The experimental results shows that the compressive and flexural strengths significantly improved at the 7th day and 28th day of the cement mortars mixed with the nano-particles. V.R.Rathi[12] reviews the efforts, current status, and effect of various nano materials on properties of cement mortar and concrete due to its large surface area It improves compressive, flexural strength, hydration characteristics and reduced porosity and water absorption. G.QUERCIA[13] aims to present the state of the art of nano silica(nS) application in concrete. It elaborates the nS production process, their addition effect and their application in concrete. A.Boshehrian[14] studied the mechanical properties, durability and microstructural properties of interfacial transition zone (ITZ) of mortars applicable for the casting of ferrocement elements reinforced with nano-SiO2 particles. The behavior was studied for the low replacement ratio of nano-SiO2 particles respect to cement in Ordinary Portland Cement (OPC) mortar mixture (including 1%, 2% and 3%), water to binder ratio (including 0.35, 0.4 and 0.5), and also sand to binder ratio (including 2 and 2.5). ABD EL-BAKY[15] he studied to investigate the properties as workability, compressive and flexure strengths by adding nano silica particle Nano-silica particles with size of 19 nm have been used as a cement addition by 1, 3, 5, 7 and 10 % by weight of cement content. Cement mortar workability decrease with increasing nano-silica addition percentage of 7 % of nano-silica recorded as optimum percentage in compressive and flexure strength measurement.

III. MATERIALS AND EXPERIMENTAL PROGRAMME

Ordinary Portland cement of 53 grade conforming to Is 12269-1987and procured from a single source is used for this investigation. The specific surface area is 303m^2/kg. The initial setting time was 70 minutes and final setting time 510 minutes. The compressive strength of cement mortar for 3days, 7 days, 21 days and 28 days was found to be 52.5N/mm^2, 67 N/mm^2, 73 N/mm^2 and 77.4 N/mm^2. The locally available natural river bed sand free from debris is used for fine aggregate and nano-silica is obtained by grinding the silica for 120 hours in high energy ball grinding milling machine. Good quality hard broken stones are used for coarse aggregate. The aggregates comply with IS383-1970 requirements. The potable water drawn from siruvani water resources was used. Silica fume procured from single source is used and it took 5 hours of grinding to get nano size beyond which the particle agglomerates. in high energy ball grinding milling machine Fly ash used in this investigation is procured from mettur thermal power station conforming to IS 3812: 1981. Fly ash is an inorganic residue and its constituents are silica, alumina and iron oxide with smaller amount of calcium, magnesium and sulphur The particle size of fly ash is generally 10µm to 300µm. This glassy fly ash is grinded for 30 hours in high energy ball grinding milling machine to produce nano-fly ash. In high energy ball grinding milling machine, 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 nano-flyash. Fig.1 shows the SEM picture of nano-fly ash, nano-silica and nano-silica fume. Nano-concrete was made by replacing 0%, 10%, 20%, 30%, 40% and 50% of fine aggregate with nano-fly ash, nano-silica and nano-silica fume for M20, M30, M40 and M50 grades.

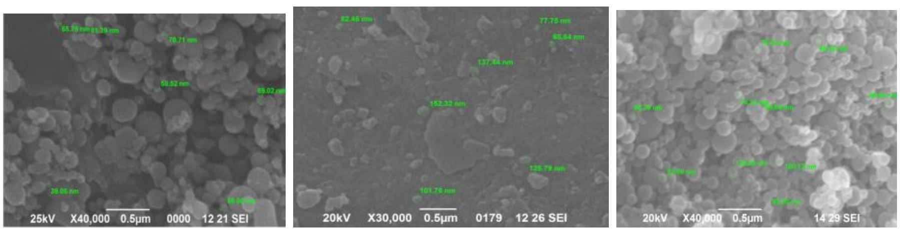

FIG 1. SEM picture of nano-fly ash, nano-silica and nano-silica fume

The compressive strength and split tensile strength of hardened concrete with nano-fly ash was found using a compression testing machine of capacity 2000kN. The compressive strength is determined as per IS 516 -1959 and the split tensile test is performed as per IS5816 – 1999 The flexure strength was performed in Universal Testing machine by applying third point loading as per IS 516-1959.

IV. FLEXURAL STRENGTH PROCEDURE

The flexure strength was performed in Universal Testing machine by applying third point loading as per IS 516-1959The value of the modulus of rupture (extreme fiber stress in bending) depends on the dimension of the beam and manner of loading. The system of loading used in finding out the flexural tension is central point load and third point loading. In the central point loading, maximum fiber stress will come below the point of loading where the bending moment maximum. In this method of testing aim is to determine the flexural strength of concrete specimen. It is used the apparatus are Tamping rod, trowels, Universal Testing Machine and standard beam size (100x100 x 500mm).The specimen are casted for standard size and particular days curing and the specimen is removed from water and surface dried. The specimen is placed in the testing machine such that the load is applied to the uppermost surface as cast in the mould, along the two lines placed 13.33cm apart.

Fig 2 Specimen before testing

Fig 3 Flexural strength Testing using UTM

The flexural strength is determined as per IS 516 – 1959. Specimens of size 500mmx 150mmx 150mm were casted. The specimen is placed in such a manner that the load is applied on the upper most surface as cast in the mould along two lines spaced 13.3cm apart. Te rate of loading is maintained at 7N/mm^2/min. The experimental setup is shown in Fig.3.

The flexure strength of concrete with and without nano-fly ash for replacement of coarse aggregate and the percentage difference in flexural strength with respect to normal Cement concrete is given in Table 3.

Table 3. Flexural Strength when Coarse aggregate replaced with nanoflyash

% replacement of nano particles	Flexural strength N/mm^2 (coarse Aggregate replaced with nano-flyash)					
	Nano-flyash					
	28 days	% Difference when compared with 0%	56 days	% Difference when compared with 0%	90 days	% Difference when compared with 0%
0	3.35		3.71		5.69	
10	4.36	23.17	5.38	31.04	6.92	17.77
20	5.28	36.55	6.13	39.48	7.26	21.63
30	5.49	38.98	6.00	38.17	7.77	26.77
40	5.96	43.79	6.70	44.63	8.99	36.71
50	5.69	41.12	6.30	41.11	8.45	32.66
0	4.80		5.21		6.89	
10	5.46	12.09	6.34	17.82	7.68	10.29
20	6.49	26.04	6.88	24.27	7.94	13.22
30	6.89	30.33	7.47	30.25	8.32	17.19
40	7.56	36.51	7.83	33.46	8.78	21.53
50	7.41	35.22	7.64	31.81	8.43	18.27
0	5.76		6.27		8.04	
10	5.97	3.52	7.37	14.93	8.12	0.99
20	7.39	22.06	7.95	21.13	8.66	7.16
30	7.87	26.81	8.12	22.78	8.76	8.22
40	8.07	28.62	8.46	25.89	9.20	12.61
50	7.85	26.62	8.35	24.91	8.90	9.66
0	6.79		7.28		8.41	
10	6.43	-5.60	7.97	8.66	8.90	5.51
20	7.78	12.72	8.06	9.68	9.18	8.39
30	8.20	17.20	8.44	13.74	9.56	12.03
40	8.68	21.77	8.96	18.75	9.76	13.83
50	8.47	19.83	8.76	16.89	9.43	10.82

V. RESULT ANALYSIS AND DISCUSSION

The variation of the 28th day, 56th day and 90th day flexural strength with respect to the percentage replacement of coarse aggregate with nano-flyash are shown in Fig.4., Fig.5. and Fig.6.

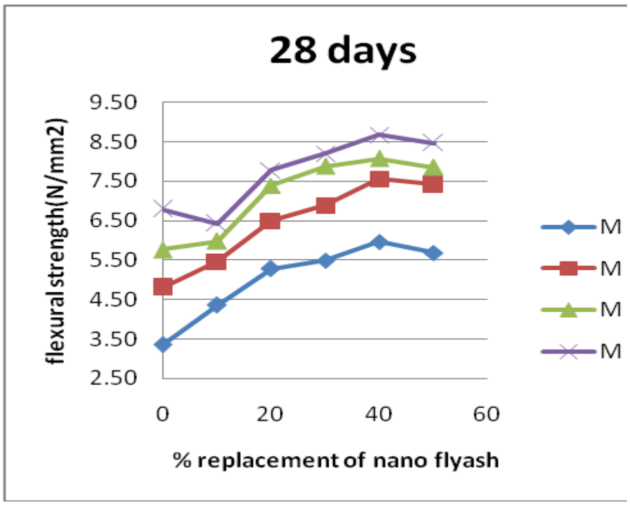

Fig.4. Flexural strength for 28 days

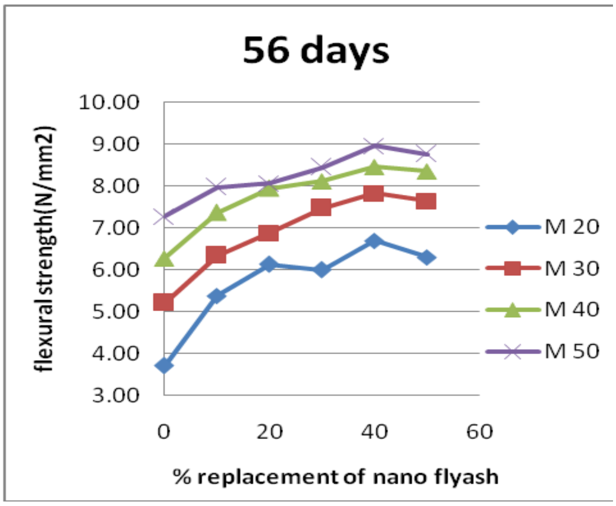

Fig.5. Flexural strength for 56 days

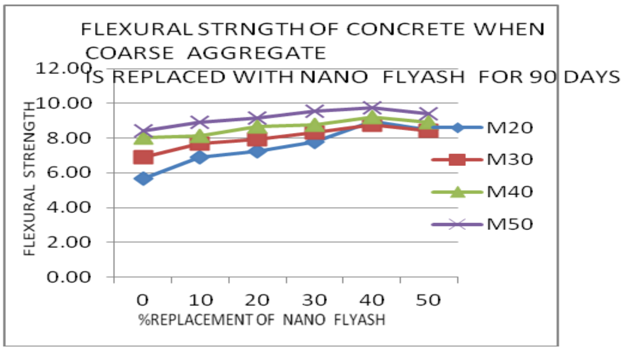

Fig.6. Flexural strength for 90 days

VI. CONCLUSION

The strength of concrete with nano-materials was found to be higher than that of Normal Cement Concrete. The flexural strength of the concrete replacing coarse aggregate with nano-flyash was found to increase upto 40% replacement.

REFERENCE

[1]. Gengying Li, 2003, "Properties of high volume fly ash concrete incorporating nano-sio$_2$" Cement and Concrete Research, 34, pp 1043-1049.

[2]. Hui Li, et al., 2004, "Microstructure of cement mortar with nano-particles" Composites Part B – Engineering, 35, pp 185-189.

[3]. Hui-gang Xiao, et al., 2004, "Mechanical and pressure-sensitive properties of cement mortar with nanophase materials" Cement and Concrete research, 34(3), pp 435-438.

[4]. Perumalsamy Balaguru and Ken Chong., 2006, "Nanotechnology and Concrete Research Oppurtunities" Proceedings of ACI Session, pp 19-28.