INFLUENCE OF NANO-ADDITIONS ON GEOPOLYMER CONCRETE

Mainak Ghosal*

Prof.Arun Kumar Chakraborty**

ABSTRACT: Flyash, the main constituent of geopolymer concrete has shown to possess excellent binding properties in the presence of sodium hydroxide & sodium silicates. Though the mechanical strength of the geopolymer concrete is attainable, the overall use of geopolymer is restricted owing to its placing problems due to occurrence of flash set.

This paper aims to investigate on the behaviour of geopolymer concrete with & without the presence of Nano-Silica(nS) and Carbon Nanotubes(CNTs).The fresh properties of the test samples prepared showed an increase in workability of more than 20% for geopolymer concrete with nS addition & more than 30% with CNTs addition, when compared to that of geopolymer concrete without nS.Contextually, it is also seen that the compressive strength of ordinary Portland cement(OPC)mortar increases by 31% at 7 days & 32% at 28 days after optimisation with nS and by -10.14% & 37.19% at 28 days after optimisation with CNTs when compared with controlled OPC mortar.However,the strength of geopolymer concrete when repeated with the same optimisation of nS & CNTs finds a decrease in strength by 11% at 7 days & 21% at 28 days when compared to geopolymer concrete without nS addition.

Keywords: Concrete,Geoplymer,Nano,Optimisation,Strength

* Research Scholar, Indian Institute of Engineering Science & Technology, Shibpur

** Associate Professor,Deptt. of Civil Engg., Indian Institute of Engineering Science & Technology, Shibpur

1.0 INTRODUCTION:

The History of Geoplolymers dates back to Egyptian Pyramid Stones and Roman era.According to one of the noted researcher,ancient Egyptians knew how to generate a geopolymeric reaction in the making of a re-agglomerated limestone block,which was used as Pyramid stone.In the 1930s, alkalis such as sodium and potassium hydroxide were originally used to test iron blast furnace ground slag to determine if the slag would set when added to Portland cement. Davidovits(1988;1994) first proposed that an alkalne liquid could be used to react with the silicon(Si) and the aluminium(Al) in a source material of geological origin or in by-product materials such as low-calcium flyash to produce binders.Because the chemical reaction that takes place in this case is a polymerization process, he coined the term 'Geopolymer' to represent these binders.The alkaline liquids are from soluble alkali metals that are usually Sodium or Potassium based.The most commonly used alkaline liquid in geopolymerisation is a combinaton of sodium hydroxide(NaOH) or pottasium hydroxide(KOH) and sodium silicate or potassium silicate. It is now being progressively accepted that, risings from coal ash and comparable materials,geoplymer binders and concretes would be ushering an era of real green construction technology.Geopolymers are alkali activated alumina silicate binders formed by the reaction of silica & alumina with alkali solutions at a relatively low elevated temperature environment of about 60-80°C [9].It is essentially concrete without cement i.e. cement free concrete. Portland cement production emits a huge amount of CO_2 (Approximately 1 ton of OPC production releases 1 ton of CO_2).India is the second larger producer of cement & by 2025 it is expected that it will surpass even China's when our population exceeds that of China, however, if both per capita cement consumption equals.However,Geoplymer concrete is not used widely in India due to its placing problems and also owing to economic reasons[7,8].In this paper an attempt has been made to find out whether the same optimisation for nano materials as found for ordinary cement mortar could influence both the fresh and hardened properties of Geopolymer concrete.

With such a looming carbon footprint & with the generation of electricity being overwhelmingly dependent on combustion of coal it is expected that India in near future will have to impose a CO_2 tax in order to meet its revenue demands. The Planning Commission of India says a 100% utilization of flyash for the next three to four years but with the current stagnation of 50% utilization (though mainly by the cement companies), it is expected that our commercial application of geopolymer concrete using flyash sets pace from the present chemistry domain of research.

2.0 MATERIALS & METHODS:

2.1 The Materials used are as follows.

a) Cement : OPC(43 Grade)
b) Coarse Aggregate: Pakur Variety
c) Fine Aggregate: River sand
d) Water: Drinking water
e) Chemical Admixture: Poly Carboxylate Ether(PCE)
f) Nano Additions: Nano-Silica(nS) & Carbon Nanotubes(CNT)
g) Flyash : From Thermal Power Plants
h) Alkaline liquid consisting of sodium hydroxide & sodium silicates in the ratio of 1:2.5

The following Tables (1 & 2) below shows the specific properties of Nano Silica & Carbon Nanotubes respectively.

Table 1 Specific properties of Nano Silica (SiO_2)

SAMPLE (BRAND)	% CONTENT(LIT.)	SPECIFIC GRAVITY(LAB)	% CONTENT(LAB)	SPECIFIC GRAVITY(LIT.)
XLP	14-16%	1.12	21.4%	1.08-1.11
XTX	30-32%	1.16	40.74%	1.20-1.22
XFXLa	40-43%	1.24	41.935%	1.30-1.32

Table 2 Specific properties of Industrial Grade Multiwalled Carbon NanoTubes (MWCNT)

DIAMETER	20-40nm
LENGTH	25-45nm
PURITY	80-85%(a/c Raman Spectrometer & SEM analysis)
AMORPHOUS CARBON	5-8%
RESIDUE(CALCINATION IN AIR)	5-6% by Wt.
AVERAGE INTERLAYER DISTANCE	0.34nm
SPECIFIC SURFACE AREA	90-220 m^2/g
BULK DENSITY	0.07-0.32gm/cc
REAL DENSITY	1-8 gm/cc
VOLUME RESISTIVITY	0.1-0.15 ohm.cm(measured at pressure in powder)

And the following Figures (1 & 2) below shows the characterizations (XRD images) of Nano Silica & Carbon Nanotubes respectively.

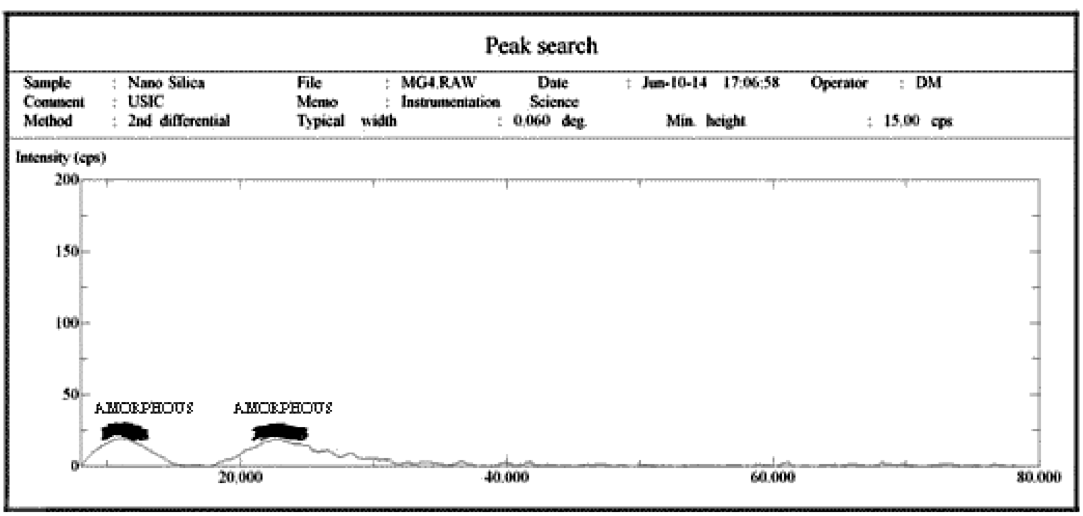

Figure 1 XRD image of Nano Silica used

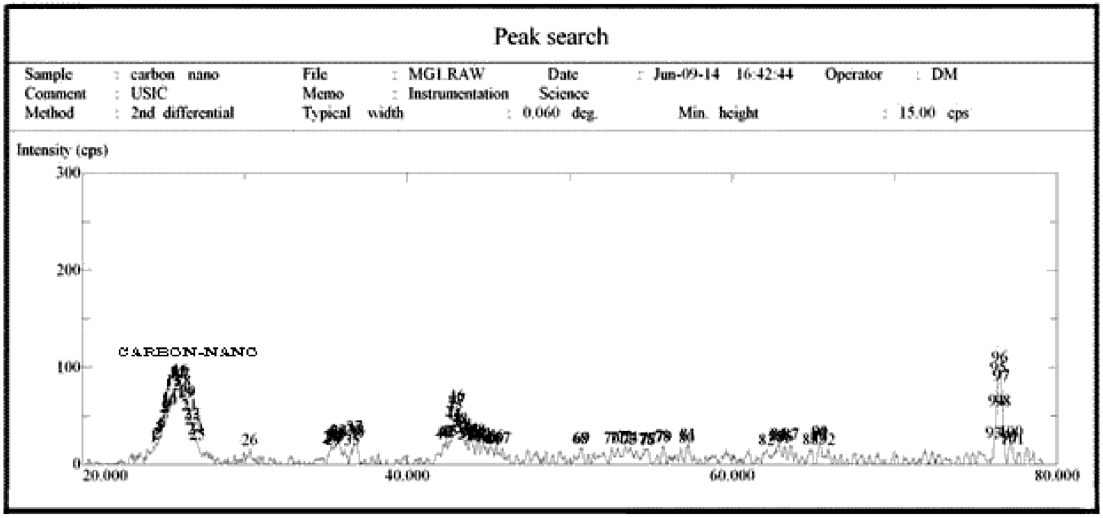

Figure 2 XRD image of Carbon Nano Tubes used

2.2 Methodology.

Test 1: For ordinary cement mortar preparation the cement: sand ratio is kept at 1:3 and water added as required for normal consistency with & without nS/CNT additions. The % of nS added varied from 0%,0.5%,0.75%,1.0%,1.25% & 1.5% w.r.to cement weight, while the weight of CNTs added are 0.02%,0.05% & 0.1% w.r.to cement wt.

Test 2: For geopolymer concrete, taking alkaline liquid to flyash ratio by mass = 0.44 & water to geopolymer ratio of 0.25 & assuming that the combined aggregate occupies 79% of the geopolymer concrete (density=2400kg/m^3) by mass, a design mix was prepared with & without nS additions.

The Mix Design for geopolymer concrete with nS additions were

20mm aggregte=3.33Kg;16mm aggregte=3.33 Kg;12.5mm=4.99 Kg;10mm=4.99 Kg;4.75mm=6.66Kg;sand=9.98Kg;FlyAsh=6.14Kg;Alkalinesolution=2.7Kg;nS=0.046Kg; Extra Water=0.31Kg

The Mix Design for geopolymer concrete with CNT additions were

20mm aggregte=3.33Kg;16mm aggregte=3.33 Kg;12.5mm=4.99 Kg;10mm=4.99 Kg;4.75mm=6.66Kg;sand=9.98Kg;FlyAsh=6.14Kg;Alkalinesolution=2.7Kg;CNT=0.00122Kg;Extra Water=0.33Kg;PCE(2% of Flyash)=0.123Kg

Figure 3 Geopolymer mixing

Figure 4 Geoplymer concrete casting

Figure 5 Curing chamber

3.0 TEST REULTS & DISCUSSIONS:

Table 1: Results of Test 1(in N/mm^2)(Mpa)

% of nS in OPC Mortar	7 Days	28 Days
0%	21.08	31.89
0.5%	23.85	35.51
0.75%	27.73	42.27
1.0%	25.07	37.36
1.25%	23.17	30.85
1.5%	23.81	37.79

% of CNT in OPC Mortar	7 Days	28 Days
0%	21.08	31.89
0.02%	17.69	43.75
0.05%	27.19	34.88
0.1%	21.69	24.83

Table 2: Results of Test 1(in N/mm^2)(Mpa)

% of Nano Materials in Geopolymer concrete	**7 Days**	**28 Days**	**Slump Value(mm)**
0% by wt. of flyash	21.18	24.48	90-130
nS=0.75% by wt. of flyash	18.79	19.11	120-145
CNT=0.02% by wt. of flyash	17.11	18.92	120-160

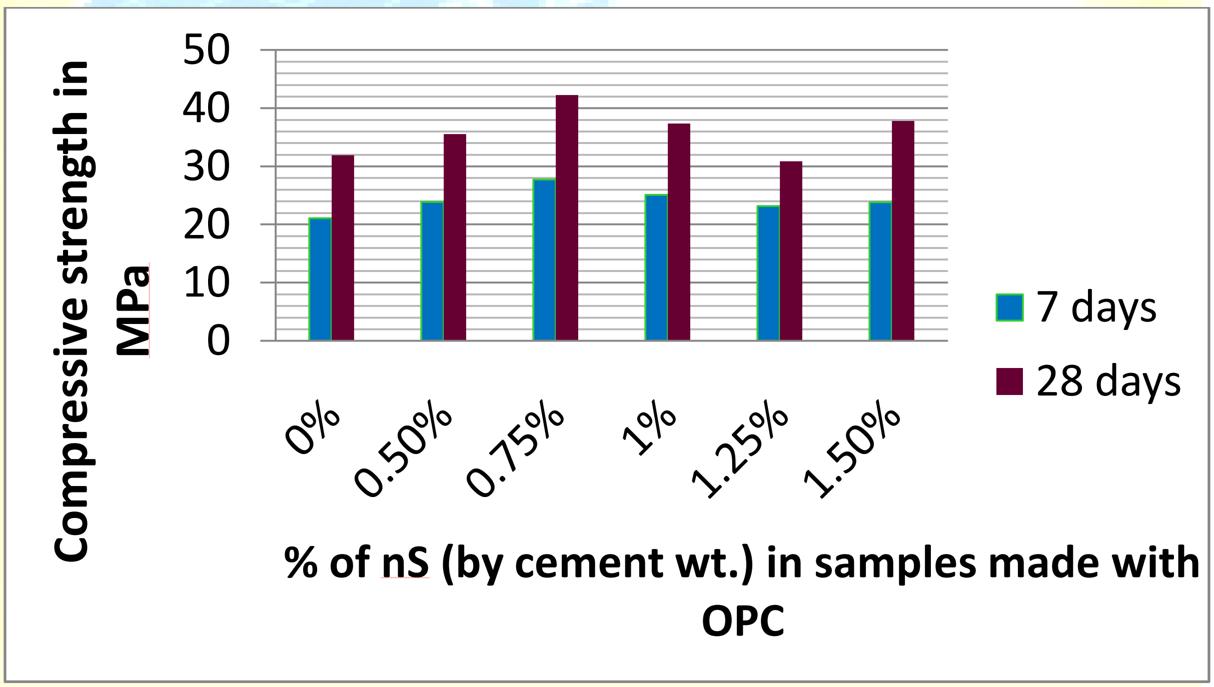

Figure 6 Graph showing strength of OPC mortar samples with nS addition

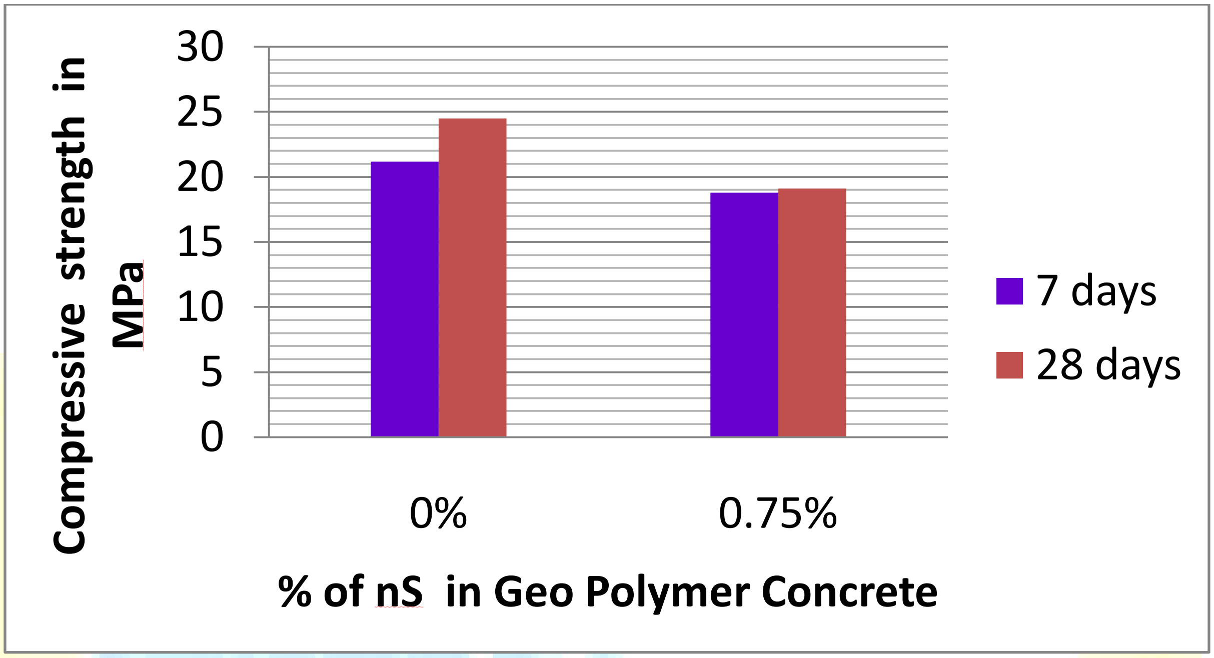

Figure 7 Graph showing strength of Geopolymer concrete samples with nS addition

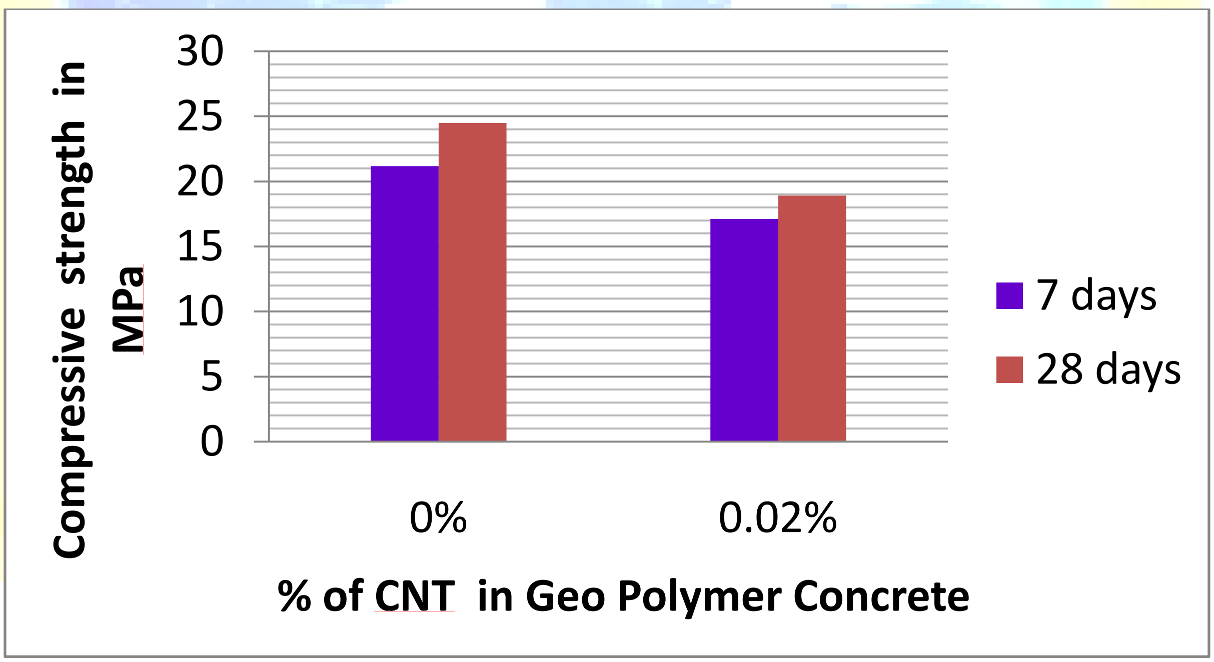

Figure 8 Graph showing strength of Geopolymer concrete samples with CNT addition

The test results showed that the fresh properties of the test samples prepared showed an increase in workability (reaching a High Range as per IS:456-2000) of more than 20% for geopolymer concrete with nS addition when compared to that of geopolymer concrete without nS(of Medium Range as per IS:456-2000).Contextually, it is also seen that the compressive strength of ordinary Portland cement(OPC)mortar increases by 31% at 7 days & 32% at 28 days(attaining a maximum of 42.27N/mm^2) after optimisation with nS when compared with controlled OPC mortar.However,the strength of geopolymer concrete when repeated with the same optimisation of nS finds a decrease in strength by 11% at 7 days & 21% at 28 days when compared to geopolymer concrete without nS addition.

4.0 CONCLUDING REMARKS:

It is concluded that with optimised nS addition the strength of OPC mortar increases appreciably for both 7 days and 28 days respectively but decreases when the same optimisation is repeated in geopolymer concrete. However, the workability of geopolymer concrete under the above optimisation produces a mix having 20% more slump value than that of ordinary geopolymer concrete. More research work is currently on the anvil to find out the exact optimisations for Nano additions in geopolymer concrete as found out in case of OPC Mortar.

The results indicate that inclusions of nS influences the strength of OPC Mortar & also the workability of geopolymer concrete to a fair level but the strength of the geopolymer concrete decreased as the exact particular optimisation of nS & CNTs for geopolymer concrete is yet to be achieved.More research work is going on to find out the exact optimization of nS in geopolymer concrete.

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