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Properties of High Strength Concrete Incorporating Colloidal Nano-Al_2O_3

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ABSTRACT: Nano technology improves the properties or develope totally new properties of material. Addition of ultra-fine particles to the cement mortar or concrete, fill the voids between cement particles & make it dense, compact which results in improved properties. In this paper, work consists of addition of 1%, 2%, 3% & 4% of colloidal nano alumina particles by wt. of cement to the concrete mixture and comparison of it with normal control concrete **(**concrete without colloidal nano alumina). For this, M60 grade mix design was selected with w/c ratio 0.26 and constant dose of superplastisizer 1%. In this work, mechanical properties are investigated through compression, flexural and split tensile strength after 28 days of curing. Results of this study showed that colloidal Al_2O_3 nano particles are very effective in improvement of mechanical properties of concrete.

KEYWORDS: Colloidal Nano-Alumina, Mechanical Properties, Strength, Concrete, Nano Technology.

I. INTRODUCTION

The main ingredients of the concrete are cement paste & aggregates. Concrete is a material in which aggregates are enclosed in a cement paste. To increase the strength of concrete adhesion between aggregate surface and cement paste and also strength of these materials plays important role. However with the advancement in concrete technology and availability of various nano material and mineral, high strength concrete can now be produced.

Now a days nano technology has great importance because of the use of nano scale particles results in significantly improved properties. Nano-technology is commonly defined as **'understanding, control, and restructuring of matter on the order of nano meters i.e. less than 100 nm to create materials having fundamentally new properties and functions'**. Use of nano material in concrete results in, dense and compact microstructure by filling the voids, accelerate the hydration reaction, create better bond between cement paste and aggregates, as they are having high surface area.

Many investigations are carried out on addition of nano-silica, nano clay, nano titanium and carbon nano tubes to improve properties of cement mortar or concrete, but addition of nano alumina increases hydraulic activity of materials which are slowly reactive & improve strength of concrete at early ages.

II. LITERATURE REVIEW

Many researches have been carried out related to improvement of strength and various parameters of concrete using nano materials. These are enumerated as, **A.H.Shekaria** has studied mechanical properties and durability of concrete using nano materials such as titanium, ferrous oxide, zirconium, and alumina. Results showed that nano alumina is most effective nano particle. **Ali Nazari, Shadi Riahi** studied mechanical and physical properties of concrete, incorporating nano alumina in concrete and curing in different media. Results indicate that nano alumina improve mechanical and physical properties of concrete. **Ali Nazari, Shadi Riahi** has studied addition of nano silica and nano alumina in concrete ,using different curing media. Abrasion resistant and compressive strength of concrete are found out. Results of study showed that abrasion resistance was more for the specimen which contain silica nano particles in both water curing and saturated limewater curing. **Amal R. Jayapalan, Bo Yeon Lee** studied influence of nano and micro materials on early age properties of cementitious material. Results indicated that, as the size of fillers is changed,

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shrinkage and pore structure of concrete can be changed**. Kiachehr Behfarnia**, **Niloofar Salemi** studied mechanical properties and frost resistance of concrete using nano materials such as nano alumina and nano silica. Results showed that with addition of same amount of nano alumina and nano silica, frost resistance was better for concrete containing nano alumina, while compressive strength was better for concrete containing nano silica. **Payam Hosseini, Reza Hosseinpourpia** has studied interaction between different nano materials (nano clay, nano alumina, nano silica and nano calcium carbonate) and aminosilane in cement mortar. Results indicated that, use of aminosilane with nano clay and nano silica gives higher mechanical performance than nano alumina and nano calcium carbonate. **Zhenhua Li, Huafeng Wang** cylindrical specimen containing different amount of nano alumina were casted to study compressive strength and elastic modulus of cement composite. Elastic modulus was increased by 143%, with the addition of 5% nano alumina after 28 days of curing and compressive strength increased by 30 %, with the addition of nano alumina 7% after 7 days of curing. Thus nano alumina increased both elastic modulus and compressive strength.

III. EXPERIMENT

Raw materials

In this study materials, Ordinary Portland cement (Birla Super Cement) of 53 grade, crushed sand, coarse aggregate, P.C. 163 H.R. Jonsan super plasticizer, water and colloidal nano alumina supplied by United Nanotech Pvt. Ltd. Was used. Main properties of colloidal nano alumina are listed in table1.

Table1. Properties of colloidal nano Al_2O_3

Sr. No.	Property	Analysis
1	Appearance	White suspension
2	Odour	Nil
3	Active component	~10%
4	Sp. Gravity	1.0-1.1
5	pH	~6.0
6	Particle size	5-8 nm

Concrete mixtures

Experimental work consists of addition of 1%, 2%, 3% & 4% of colloidal nano alumina particles by wt. of cement to the concrete mixture and comparison of it with normal control concrete. For this, M60 grade mix design was selected with w/c ratio 0.26 and constant dose of superplastisizer 1%. In this work, mechanical properties are investigated through compression, flexural and split tensile strength after 28 days of curing. Table 2 shows mix proportion of concrete

Table2. Mix proportion of concrete

Sample	Cement (kg/m^3)	S.PL (%)	W/C	Colloidal nano-alumina% (CNA)
NCC	540	1	0.26	0
CNA1	540	1	0.26	1
CNA2	540	1	0.26	2
CNA3	540	1	0.26	3
CNA4	540	1	0.26	4

*Note- NCC denotes normal control concrete (concrete without colloidal nano alumina) and CNA denotes colloidal nano alumina.

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Experimental procedure

The fresh concrete casted in 150 X150X150 mm cubic, 150X150X700 mm beam and 300X150 mm cylindrical moulds. After demoulding at the age of 1 day, curing was done in water for 28 days and after 28 days tests were conducted.

1. Compression test
Compression tests were conducted on cube sample of concrete. For each mixture, three cubes were tested under Compression testing machine of 3000 KN capacity.

2. Split tensile test
Split tensile tests were conducted on cylindrical concrete sample. For each mixture, three cylinders were tested under Compression testing machine.

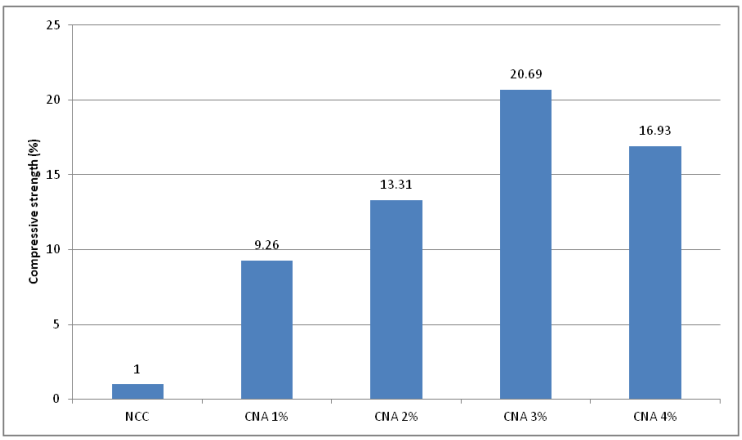
3. Flexural test
Flexural strength tests were conducted on beam sample of concrete. For each mixture, three beams were tested under Universal testing machine of 400 KN capacity.

IV. RESULTS AND DISCUSSIONS

Test results of the compression strength are shown in table 3. and graph 1. As shown in table 3 and graph 1, compressive strength developed in every case of concrete containing colloidal nano alumina is higher than the normal control concrete specimen (concrete without CNA). It is also indicated that, compressive strength of concrete specimen increases from 1% to 3% addition of CNA in concrete specimen and after 4% it decreases. Addition of CNA 3% by wt. of cement in concrete results, maximum increase in compressive strength 20.69% as compared to normal control concrete.

Table 3. Compressive strength of specimens after 28 days

Specimen	Compressive strength (MPa)	% increase or decrease in compressive strength
NCC	69.1	1
CNA1	75.5	9.26
CNA2	78.3	13.31
CNA3	83.4	20.69
CNA4	80.8	16.93



Graph.1 Compressive strength of specimen

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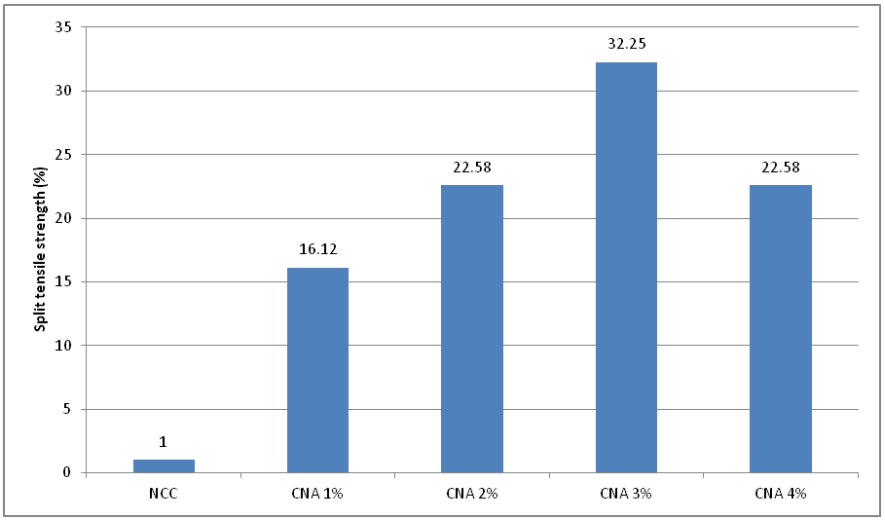
Test results of the split tensile strength are shown in table 4. and graph 2. As shown in table 4 and graph 2. It is indicated that, split tensile strength of concrete specimen increases from 1% to 3% addition of CNA in concrete specimen and after 4% it decreases. Addition of CNA 3% by wt. of cement in concrete results, maximum increase in split tensile strength 32.25% as compared to normal control concrete.

Table 4. Split tensile strength of specimens after 28 days

Specimen	Split tensile strength (MPa)	% increase or decrease in split tensile strength
NCC	6.2	1
CNA1	7.2	16.12
CNA2	7.6	22.58
CNA3	8.2	32.25
CNA4	7.6	22.58



Graph.2 Split tensile strength of specimen

Test results of the flexural strength are shown in table 5. and graph 3. As shown in table 5 and graph 3. It is indicated that, flexural strength of concrete specimen increases from 1% to 3% addition of CNA in concrete specimen and after 4% it decreases. Addition of CNA 3% by wt. of cement in concrete results, maximum increase in flexural strength 37.31% as compared to normal control concrete

Table 5. Flexural strength of specimens after 28 days

Specimen	Flexural strength (MPa)	% increase or decrease in flexural strength
NCC	6.7	1
CNA1	8.3	23.8
CNA2	8.8	31.34
CNA3	9.2	37.31
CNA4	8.6	28.35

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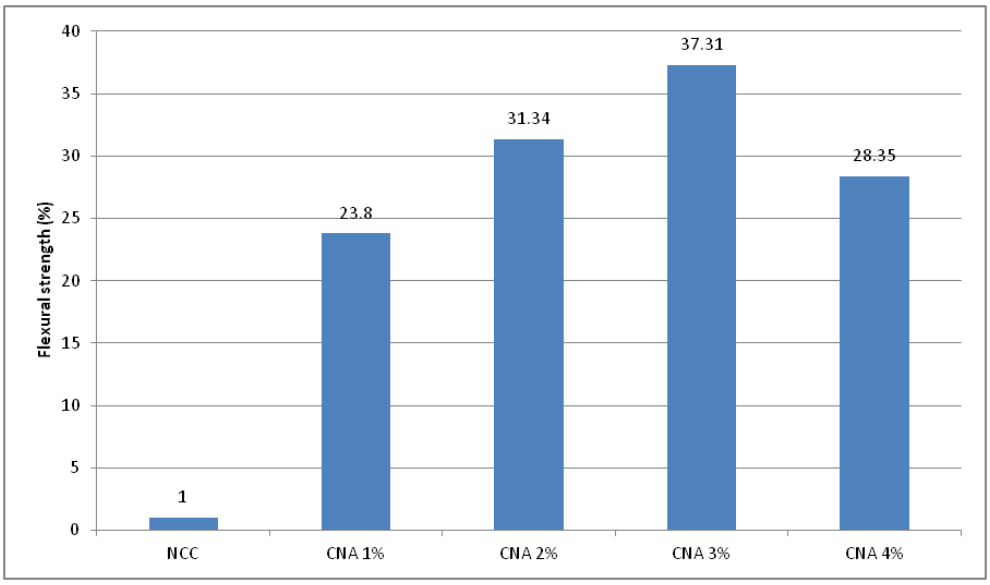

Graph.3 Flexural strength of specimen

V. CONCLUSION

Compressive, split tensile, flexural strength of concrete specimen containing 0%,1%, 2%,3% and 4% of colloidal nano-Al_2O_3 particles were investigated. Samples containing 3% colloidal Al_2O_3 nano particles, shows better mechanical properties than normal control concrete. Increasing colloidal nano-Al_2O_3 more than 4 % by wt. of cement, reduces the mechanical strength of concrete.

Colloidal nano-Al_2O_3 particles are very effective in improving the mechanical properties of the concrete.

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