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Effect on High Strength Concrete by Partial Replacement of Cement with Nano Alumina Micro Alumina and Fly Ash

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Abstract

In this research study, the effect on High Strength Concrete(HSC) by partial replacement of cement with Nano alumina, micro alumina and fly ash on the mechanical properties of the concrete is studied. In this investigation the cement is replaced by 20% Fly-ash, 5% micro alumina and Nano alumina of different proportion i.e 0%, 0.25%, 0.5%, 0.75%, 1% in M60 grade of concrete. It is observed that the concrete's workability is reduced by increasing the content of nano alumina from 0% to 1% and constant micro alumina particles of 5% cement (by wt.) and fly ash of 20% cement(by wt.). The results showed that 0.75% of the combination of Nano alumina, micro alumina and fly ash increases the properties of the high strength concrete. The microstructure characteristics results revealed that the Nano alumina, micro alumina and fly ash particles incorporated enhances the cement's mechanical strength properties and the voids were filled up with these materials.

Keywords: *Nano alumina, micro alumina, fly ash, Split tensile strength, Flexural strength.*

1. Introduction

Of all the materials used, cement is important material in concrete. Cement is produced by calcinating argillaceous and calcareous materials at a high temperature. During this procedure, enormous amount of CO_2 (i.e. 1 ton of cement=0.8 ton of CO_2) is released into the environment. Therefore decrease in the utilisation of cement will reduce the emission of CO_2. So there is necessity of replacing cement with some different materials. There is also requirement of increase the various qualities of concrete with the usage of different materials.

Nano material is defined as materials with size less than 200nm. The use of nanomaterials will improve the binding effect. It also acts as a filler agent, that helps to reduce the micropores in the concrete results in a dense concrete structure.

Fly ash reduces the C-S-H when reacts with free lime in cement during hydration. Fly ash contribute towards enhancing the properties of material, increases workability and strength, decreases heat of hydration and shrinkage.

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2. Literature review

Karthikeya Rao and SenthilKumar[1] Study on strength of GGBS and Nano Alumina on Concrete. The optimum percentage of GGBS replacement was found to be 50%, Nano Alumina particles were used in various proportions, for example 0.5% to 2% by cement volume. It is inferred that fractional change of cement with Nano Alumina and GGBS exhibits better split tensile, Flexural and Compressive quality in comparison with conventional concrete.

Agarkar and Joshi[2] Study on effect of Nano Alumina on compressive strength and workability of blended concrete. The compressive test was completed as per IS 456-2000 on Nano Alumina mixed concrete and plain mix. The tests were done on M20 grade of plain concrete and Nano alumina blended concrete. The outcomes uncovered that the compressive quality of a portion of the examples is developed. It is reasoned that partial change of cement with Nano alumina particles magnifies the compressive quality of cement yet diminishes its workability.

3. Experimental Details

3.1 Materials

3.1.1 Cement

In this investigation, 53-grade OPC Birla Shakti Company is used and its specific gravity is found to be 3.15.

3.1.2 Coarse Aggregates

Aggregates are critical constituents of concrete.70-80% of the volume of the concrete is occupied by aggregates.coarse aggregate of nominal sizes of 20mm, 12mm are used. Water absorption test value is found to be 0.25%. Fineness modulus is calculated as 7.37. Specific gravity was calculated as 2.8.

3.1.3 Fine aggregates

The important role of the aggregates is to give good workability and uniformity in concrete mixture. The fine aggregate used in this study is from local river bank chitravathi. water absorption test is performed and the value is 0.5%. Fineness modulus of fine aggregate is 3.05.The specific gravity of sand is found to be 2.60

3.1.4 Nano alumina

The properties of nano alumina are as follows

Property	**Nano alumina**
Particle density (g/cm^3)	3.6
Surface area (m^2/g)	>150
Formula	Al_2O_3
Average particle size	20-50
Solubility in water (%)	Insoluble
Colour	White

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3.1.5 Micro alumina

Micro alumina enhances the physical properties, durability and workability of concrete. It can also be used to build marine structures as it reduces the damage caused due to the reaction of chlorides and various chemicals.

3.1.6 Super plasticizer

Conplast SP430 is used to obtain high workability. Utilization of super plasticizers permits the decrease of water to the degree up to 30% without lessening workability. The utilization of super plasticizer is being used for generation of streaming, self-levelling, and self-compacting for the creation of High Strength Concrete(HSC).

3.2 Mix proportions

As per IS-10262 this investigation is done on M60 grade concrete. The proportion of mix attained is 1:1.353:2.78 with W/C ratio as 0.32. Subsequent mixes were prepared with replacement of cement partially by varying percentages from 0%, 0.25%, 0.50%, 0.75% & 1% of Nano aluminium oxide particles (Nano Al_2O_3), 5% micro alumina and 20% fly ash constant.

Table-1Trial mix proportions for 1m^3 of concrete

S.no.	Material	Quantity in kg
1.	Cement	462.5
2.	Fine aggregate	626.08
3.	Coarse aggregate(max 20 mm size)	1285.76
4.	Water	148
5.	Super plasticizer	5.55

3.3 Test Results

3.3.1 Split tensile strength

This test is done on 150 mm diameter and 300 mm length cylindrical specimens. This strength is 7-15% when compared with cube strength and Tensile strength is calculated with different rates of replacement of Nano alumina, and constant rate of micro alumina and flyash within concrete for 3,7 and 28 days has found out and values are noted in **table 2** and recorded graphically in **figure 1**. We can incur that maximum strength is obtained when cement is replaced by 0.75% nano alumina.

Table-2 Split tensile strength results for M60 mix

s. no.	**Mix Design M60+NanoAl2O3+ microalumina+ flyash (mix notation)**	**Split tensilestrength of cylinders in N/mm^2**		
		3 days	**7days**	**28days**
1	M60 (M0)	3.628	5.67	7.54

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2	M60+0.25% nano+ 20%Flyash+5% micro (M1)	3.92	6.04	8.55
3	M60+0.5%nano+ 20%Fly ash +5%micro(M2)	4.43	6.68	9.27
4	M60+0.75% nano+ 20%Fly ash+5%micro (M3)	4.94	7.27	9.83
5	M60+1%nano+ 20%Flyash+5% micro (M4)	4.758	7.245	9.72

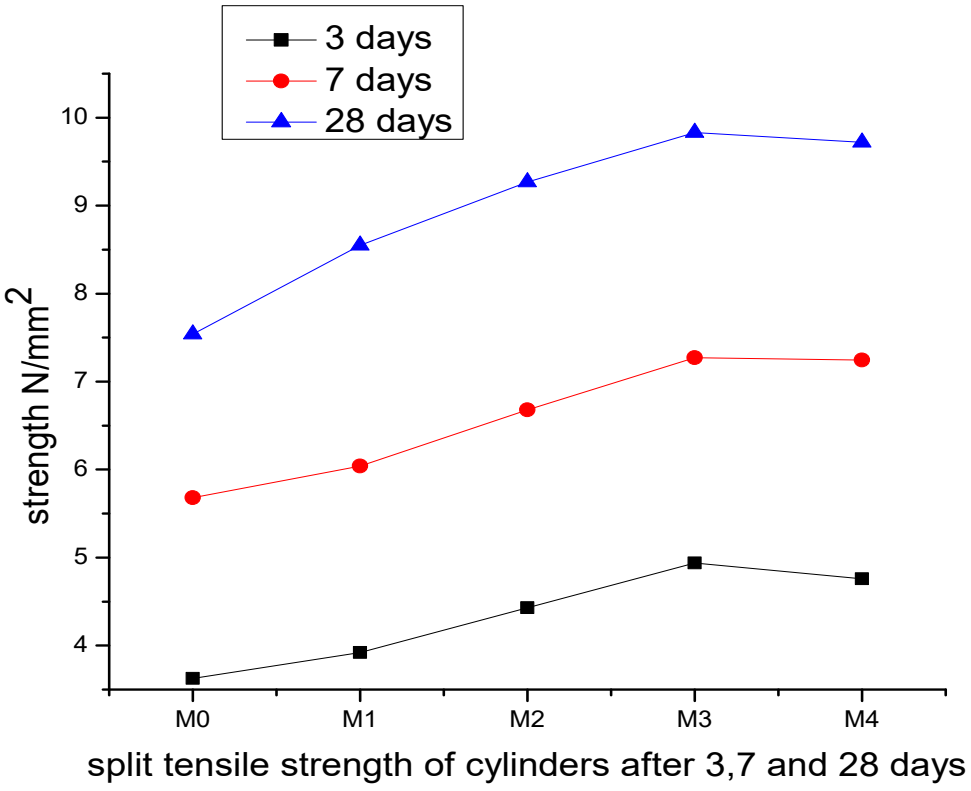

Figure-1 Split tensile strength results graph for M60 mix

3.3.2 Flexural Strength

When compared with cube compressive strength flexural strength of beams is 10% and it is done on beams of size 100mm*100mm*500mm. This strength is calculated by using

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two point loading method and it is done for 3,7 and 28 days. And these results are shown in **Table-3**and drawn graph in **Figure-2**.

Table-3 Flexural strength of beams results for M60 mix

s. no.	**Mix Design M60+NanoAl2O3+ microalumina+ flyash (mix notation)**	**Flexural strength of beams in N/mm^2**		
		3 days	**7days**	**28days**
1	M60 (M0)	3.56	5.43	7.02
2	M60+0.25% nano+ 20%Flyash+5% micro (M1)	4.02	5.78	8.408
3	M60+0.5%nano+ 20%Fly ash +5%micro(M2)	4.21	6.29	9.28
4	M60+0.75% nano+ 20%Fly ash+5%micro (M3)	4.82	6.86	9.91
5	M60+1%nano+ 20%Flyash+5% micro (M4)	4.68	6.49	9.72

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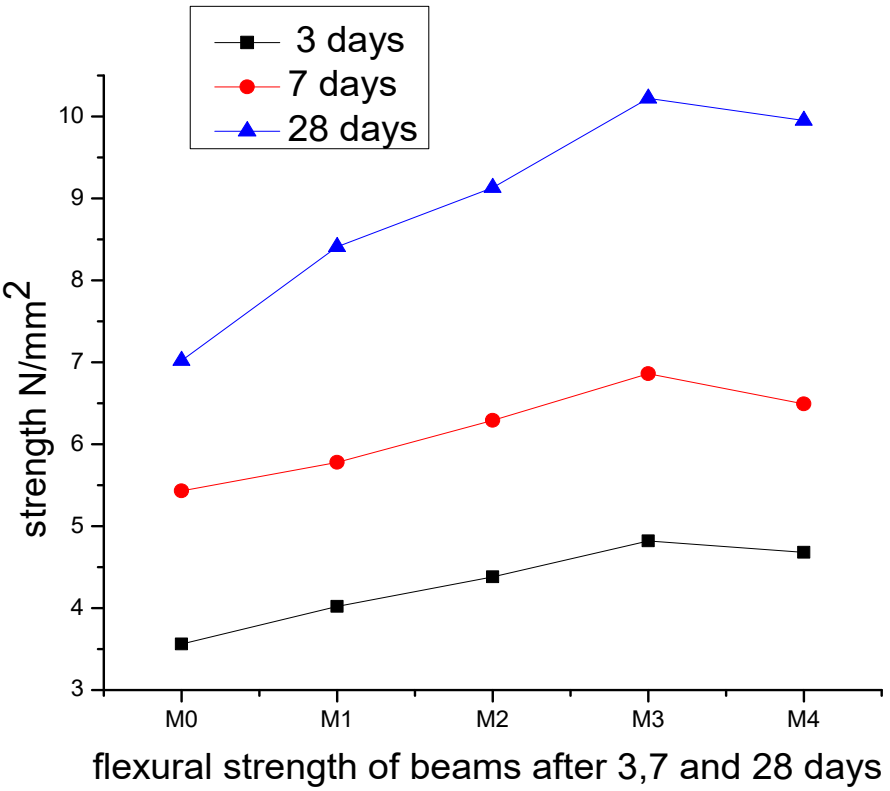

Figure-2 Flexural strength of beams results graph for M60 mix

4. Conclusions

From the above investigations, the effect of Nano alumina, micro alumina and flyash as partial substitution of cement within mix but micro alumina and fly ash is constant for all proportions adding for cement replacement, we came to following tentative conclusions:

- The results show us, constant Micro Alumina(5%), fly ash(20%) and with regular increase in nano alumina content(0.25%,0.5%,0.75%,1%) gives higher Flexure& Splitting Tensile Strengths compare to plain M60 mix.
- As Nano Alumina content increases, Flexure& Splitting Tensile Strengths increases till 0.75% & then decreases. Hence nanoalumina optimum substitution is 0.75%.
- The maximum growth in Split Tensile strength is 30.37% when compared to plain mix
- The maximum growth in Flexure Strengths is 41.17% when compared to the plain mix.
- In all 3, 7 and 28days the maximum Splitting Tensile & Flexure Strengths were obtained at 0.75% Nano alumina particles with cement replacement.
- Weight of specimens decreased when percentage replacement of cement with nano alumina increases.

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