Scientific Journal of Impact Factor(SJIF): 3.134

e-ISSN(O): 2348-4470
p-ISSN(P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 2,Issue 5, May -2015

EFFECT OF NANO SILICA ON COMPRESSIVE STRENGTH OF HIGH VOLUME FLYASH CONCRETE

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Abstract — *As the consumption of concrete increases, the world production of cement is continuing and grew to a significant amount. Portland cement production is a highly energy intensive process, and emits CO_2 during calcination which has a crucial effect on global warming. The production of one tonne of ordinary Portland cement (OPC) releases approximately one tonne of carbon dioxide to the atmosphere. In this regard it is essential to find environmentally friendly concrete containing low OPC content but with high performance in strength and durability. For many decades, the incorporation of flyash as partial replacement of cement in concrete is a common practice and along with that the use of nano particles has received particular attention in the application of construction materials especially in cement mortar and concrete.*

The basic concept behind using Nano Material which are having large surface area is to improve compressive and flexural strength at early ages, improved hydration characteristics and reduced porosity and water absorption when compared with conventional cementitious material.

In this study, effect of Nano Silica (NS) on Compressive strength of High Volume Flyash (HVFA) concrete have been analysed. The percentage of NS used for replacement were 0%, 1%, 1.5%, 2%, 2.5% by weight of cement and flyash content were 55% for all the mix. Compressive strength of concrete is tested for M50 & M60 grade of concrete. From the experimental results it is observed that as days increases compressive strength increases but as percentage of replacement of NS increases beyond 1.5%, compressive strength decreases but it is higher than the conventional concrete & normal HVFA concrete.

Keywords- *HVFA, Nano Material, Nano Silica*

I. INTRODUCTION

Concrete is actually the final product made from cement. Cement is the Principal binder in concrete. The production of cement is a major contributor to greenhouse gas emissions that are implicated in global warming and climate change. Cement manufacturing is highly energy and emissions intensive because of the extreme heat required to produce it. Around 7% of carbon dioxide (CO_2) emission is because of cement production only. It is essential to find environmentally friendly concrete containing low OPC content but with high performance in strength and durability and that are Supplementary Cementitious Materials (SCM). Fly ash is an inorganic, non-combustible by product of coal–burning power plants. Today, there is a general trend to replace higher levels of Portland cement with flyash in concrete. Addition with flyash, Nanotechnology can be used for design and construction processes in many areas since nanotechnology generated materials have many unique characteristics like small surface area. These characteristics can again significantly fix current construction problems and increase the bond strength of concrete. The use of Nano materials in the composition of cement, will result in significant reductions of CO_2 pollution and the use of performance thermal insulations will result in efficient use of energy for air conditioning.

II. OBJECTIVE

The main objective of this study is to analyze the effect of NS on HVFA concrete. The main parameters observed is compressive strength.

III. METHODOLOGY

Strength is one among the most important properties of concrete, since the first consideration in structural design is that the structural members must be capable of carrying the imposed loads. The mix of concrete used in this study is M50 & M60. Concrete mix with 0% NS is the control mix and water cement ratio adopted is 0.33 & 0.30 for M50 & M60 grade of concrete respectively in accordance with the Indian Standards specification IS 10262 - 2009. The percentages of replacements of NS are 1%, 1.5%, 2% & 2.5% by weight of cement and flyash content is fixed 55%. Tests were performed for compressive strength of concrete for all replacement levels of NS at different curing period (7 days, 28 days and 91 days).

IV. MATERIAL PROPERTIES

4.1 Cement (OPC)

The Ordinary Portland Cement of 53 grades conforming to IS: 8112 is used. The cement used is fresh and without any lumps. Physical property of cement is as in Table 1.

Table 1: Physical Properties of (OPC) Cement

Characteristic	Value
Specific Gravity	3.15
Consistency	30%
Initial Setting time	90 min
Final Setting time	178 min

4.2 Flyash

The chemical properties of flyash is as in Table 2 which is as per IS: 3812.

Table 2: Chemical Properties of Flyash

Tests	Results(%)
Silicon dioxide(%)	45
Magnesium oxide(%)	2.7
Sulpher Trioxide(%)	1.8
Aluminum Oxide (Al_2O_3)	10.6
Total loss on Ignition(%)	2

(Source: Sicart Laboratory, V.V.Nagar)

Figure 1: Flyash

4.2 Aggregate

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. The fact is that the aggregate occupy 70-80 percent of the volume of concrete. One of the most important factors for producing workable concrete is good gradation shape and texture of aggregates. Minimum paste means less quantity of cement and less water, which are further mean increased economy, higher strength, lower shrinkage and greater durability.

4.2.1 Coarse Aggregate

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Flakiness and Elongation Index were maintained well below 15%.

Table 3: Physical Properties of Course Aggregate

Characteristic	Value
Specific Gravity	2.86
Density	1620 Kg/m^3
Fineness Modulus	7.07

Figure 2: Coarse Aggregate

4.2.2 Fine Aggregate

The fractions from 4.75 mm to 150 microns are termed as fine aggregate. The river sand is used in combination as fine aggregate conforming to the Requirements of IS: 383.

Table 4: Physical Properties of Fine Aggregate

Characteristic	Value
Specific Gravity	2.6
Bulk Density	1530 Kg/m^3

Figure 3: Fine Aggregate

Fineness Modulus	3.16

4.3 Nano Silica

The properties and figure of NS are as shown in Table 5 & Figure 4.

Table 5: Properties of Nano Silica.

Properties	Unit	Typical value
Specific Surface Area	m^2/g	200 ± 25
Average Primary Particle Size	nm	12
Tamped Density	g/l	approx.50
Moisture 2 hours at 105°c	wt.%	≤ 1.5
Ignition loss 2 hours at 1000°c based on material dried for 2 hours at 105°c	wt.%	≤ 1.0
PH in 4% dispersion		3.4 – 4.7
SiO_2 – content based on ignited material	wt.%	≥ 99.8

(Source: Sicart Laboratory, V.V.Nagar)

Figure 4: Nano Silica

4.4 Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water are required to be looked into very carefully.

4.5 Moulds

Mould of size 150mm×150mm×150mm were used to prepare the cube specimens and moulds of size 150mm×300mm were used to prepare cylinder specimens for determining the compressive strength of concrete. Care was taken during casting and vibrator was used for proper compaction. All the specimens were prepared in accordance with Indian Standard Specific IS: 516 – 1959. All the moulds were cleaned and oiled properly. They were securely tightened to correct dimensions and prevent leakage of slurry.

V. EXPERIMENTAL CONSIDERATIONS

5.1 Design Mix:

A mix M50 & M60 grade was designed as per Indian Standard method (IS 10262-2009) and the same was used to prepare the test samples. The mix design is finalized by conducting number of trial mixes and chemical percentage is adopted from the experiment of Marsh cone. The design mix proportion as in Table 6.

Table 6: Mix Design

Mix	W/C	Cement	Flyash	Fine Aggregate	Coarse Aggregate		Water	Chem Admix.
					20 mm	10 mm		
M50	0.33	189	230	635	533	784	138	5.4
M60	0.3	207	253	621	510	766	138	5.9

VI. EXPERIMENTAL RESULT

5.1 Compressive Strength

The compressive strength of cube and cylinder for different replacement of NS contents (0%, 1%, 1.5%, 2% and 2.5%) and flyash content 55% at the end of 7 days, 28 days and 91 days results are given in Table 8 for M50 & M60 grade of concrete.

For M50 & M60 Grade of concrete, Figure 1 & Figure 2 represents the result value of compressive strength of cube from which it is observed that compressive strength decreases beyond 1.5% of NS. Figure 3 & Figure 4 represents the result value of compressive strength of cylinder. From the graph, it is analyzed that compressive strength results are more than normal conventional & HVFA concrete which shows the applicability of Nano silica in concrete for higher performance.

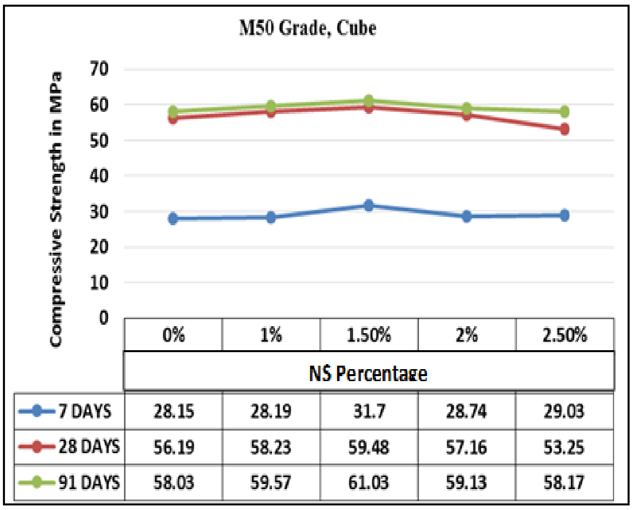

Figure 1: Compressive Strength of cube M50 Grade

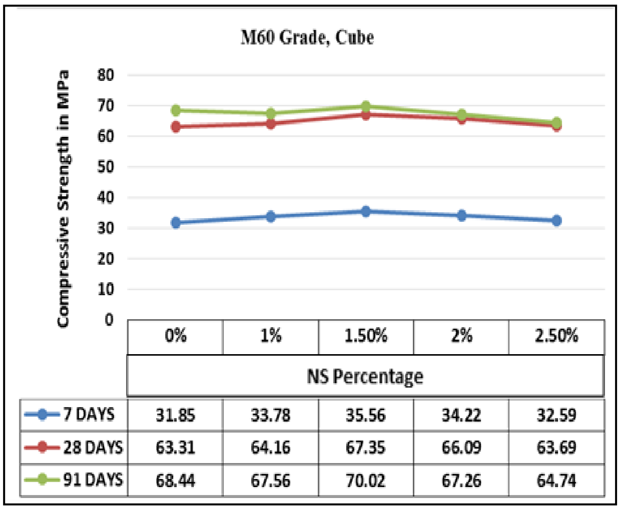

Figure 2: Compressive Strength of cube M60 Grade

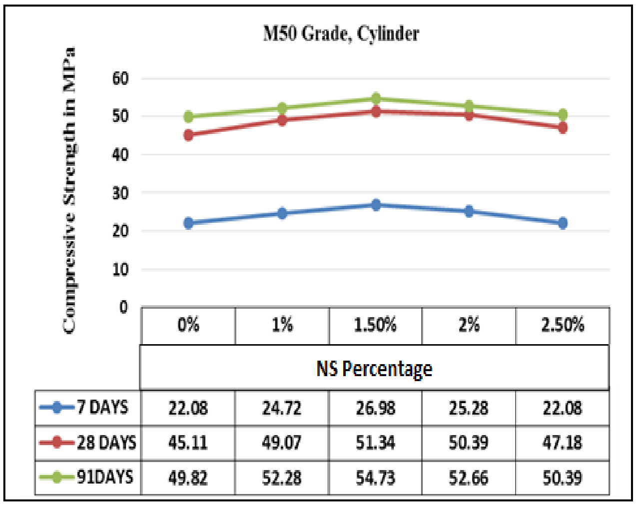

Figure 3: Compressive Strength of Cylinder M50 Grade

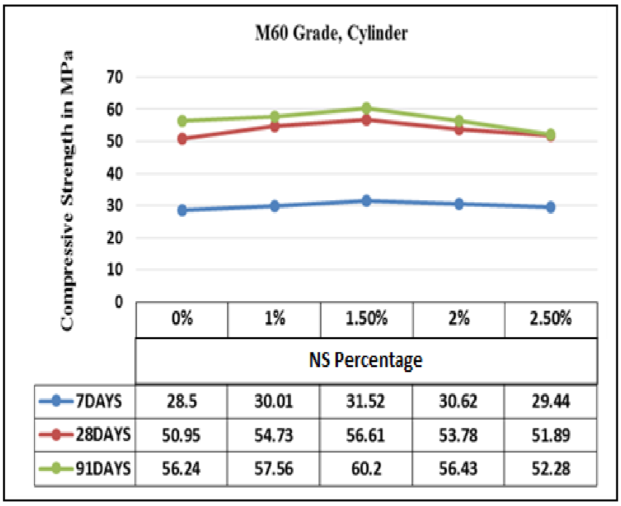

Figure 4: Compressive Strength of Cylinder M60 Grade

II. CONCLUSIONS

- Addition of NS is enhancing the Strength properties of HVFA concrete.
- NS with HVFA concrete gives higher compressive strength than conventional concrete & HVFA concrete.
- Increment of 10% compressive strength is observed in M50 and M60 grade concrete at 1.5% of NS with 55% Flyash in comparison to conventional concrete.
- The compressive strength at 91 days increases by average 2% for M50 and average 3.5% for M60 grade with reference to the test results for 28 days.
- It is found that 1.5% NS is effective replacement to improve Compressive Strength of HVFA concrete.
- By looking at the result, Manufacturing of HVFA concrete with NS can be an effective solution for making sustainable concrete.

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