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Application Of Nanotechnology Using Steel Fiber Reinforced Concrete With Stone Dust For Developing Sustainable Building Materials

Abdul Ghaffar Noor Mohd[1,a)] , Divya Prakash[2]

[1]Research Scholar, Department of Civil Engineering, Poornima University, Jaipur.
[2]Associate Professor, Department of Civil Engineering Poornima University, Jaipur.
[a)]ghaffar_structure@rediffmail.com

Abstract. Nowadays due to urbanization and industrialization, global warming is reaching an alarming level and provides adverse effects on human life as well as on climate. It's right and high time to design and develop a sustainable solution to address the serious issue. This study investigated Nano modification in the design of concrete under huge realization in the construction world. The age of concrete in the construction industry can be increased by improving the strength of concrete by utilizing the byproducts and construction waste industry because of sustainable development of building construction material and environmental protection. This is a positive step as the life of the structure is increased by using sustainable materials. Nano materials like nano-alumina, carbon nanotubes, titanium oxide, nano alumina, etc. This study reported the influence of nano-silica on mechanical properties such as compressive strength, of M35 grades of concrete with the use of optimized nano-silica as a partial replacement of cement. The experimental results were compared both with and without nano-silica in SFRC; it was found that the mechanical properties of concrete can be enhanced by nano-silica with SFRC. The design concrete is nano-silica steel fiber reinforced concrete (NSSFRC). In this research work, both hooked ends fibers are used to find the mechanical properties of concrete, with a fiber length of 60mm and diameters of 0.75 mm with a 0.45 w/c ratio.

Addition of steel fibers with volume fractions, 0.5%, 1.0%, and 1.5% and nano-silica added with different volume fractions 7.5 %, 15%, and 20% by weight of cement. Twenty-seven concrete mixes were considered for this experimentation and investigated the influenced properties of concrete. Also studied the area variation as in the case of different volume fractions of fibers. The experimental results show that the tilt towards the positive side with the addition of fiber with nano silica resulting an increase in mechanical properties of future concrete by 12-30% in compressive strength.

Keywords: SFRC, Nano silica, compressive strength, M35

INTRODUCTION

Sometimes nano-engineering and nanoscience are known as Nano modification, now in recent times, this sector has better opportunities in the world of concrete[5,6,19, and 20]. As characterization and measurement of nano and a micro-scale completely depend on the type of materials and the ingredient used as the Nano modification is a well self-explanatory modification or restructuring of the properties of the materials for improving the performance of concrete by advance adopting of recent and modern techniques at molecular level modeling or atomistic characterization techniques. In Nanoscience for the perfect understanding of cement and cement-based materials and their measurements and how it affects the micro-scale properties of the materials and manufacturing of cement concrete-based composite materials by using Nano modifications, also the effect on micro-scale properties and its performance by using advanced characterization techniques and atomistic or molecular level modeling. [1] Nobel laureate Richard P. Feynman was the pioneer of Nanotechnologyduring his famous 1959 lecture introduces this technology to the world and provide a new platform for thinking in this area. [2,3].Many emerging sectors and departments of chemistry, physics, and biology and same is idealized by Feynman's ideas to restructure the matter of materials on a very small scale to improve the properties of materials on a Nano scale level this is known as nanotechnology. The Nanotechnology description is varied concerning the country and application perspective as per the need and application of cement and concrete products. Nanotechnology is dealing with two significant methodologies: (a) ''top-down'' method, in this process of nanotechnology majorly restructuring process as foundation element is considered or reshaped the various particles with the change of actual properties for different field application purpose, e.g. miniaturization in area of electronic simply restructuring in smaller parts. (b) ''bottom-up'' is also known as molecular nanotechnology which larger structures are reduced in size to the Nanoscale while maintaining their original properties without atomic-level control (e.g., miniaturization in the domain of electronics) or deconstructed from larger structures into their smaller, composite parts and (ii) the ''bottom-up'' approach, also called ''molecular nanotechnology'' First time ''molecular manufacturing,'' discussed by Drexler et al. [3], this can be considered as new opportunities were one can improve the desirable properties of concrete by self-assembly process through any one approach as discussed in above, here one can apply this technology may contribute well as per as materials are concern in various emerging sectors like I.T, biotechnology, electronics, medical, and material manufacturing process, defense and most important application of nanotechnology in construction industry as concrete is concern as all are aware concrete is second consumed material on earth after water[4].Crucial contribution is considered in area of concrete development as cementitious material is concern with the application of nanotechnology some of mechanical properties are increased in notable manner[5,6].Due to increasing demand of cement in construction industry necessary to understand basic structure at nano scale to improve the mechanical properties of cement mainly heat of hydration, cohesion and all improve the nanostructure of cement resulting increased compressive strength of concrete use full in development of future concrete [5,7–11]. The basic aim of current experimentation is to study the variation in compressive strength of nano-silica on the mechanical properties of Steel Fiber Reinforced Concrete (SFRC).

2. MATERIALS AND METODS

2.1 Materials

2.1.1 Ordinary Portland Cement (OPC) is used for current studies referring to "IS: 12269-1987".

2.1.2. Properties of superplasticizer (SP)

The properties of the superplasticizer used for experimental work are shown in Table 01

Table 01: Properties of Super Plasticizer Used

Sr No.	Properties	Description
1.	Chemical admixture	Masterplast SPL 9-M2
2.	Natural	Single component liquid
3.	Type	Sulphonated naphthalene formaldehyde polymer
4	Specific gravity at 30^{o}C	1.27 $\pm$ 0.02
5.	Chloride content	Nil
6.	Air Entrainment	Nil
7.	Nitrate content	Nil
8.	pH Value	7-9

2.1.3. Fine(F.A) and coarse aggregates(C.A)

Physical properties of fine aggregates used were in preparation of design mix Particle shape, size 4.77 mm down, Cement fineness modulus 3.16, Sand Silt content 1.5%, Sand specific gravity 2.63, Bulking of sand 4.15%, Bulk density 1794 Kg/m3 and observed surface moisture nil.

2.1.4. Physical properties of steel fibers used

In this study, steel fiber was used confirming “ASTM 820 type A” manufactured by Dramixfor this experimental research. “Dramix RC - 80/60 – BN” is in a bunch with glued having a good resistance against tensile failure made by cold drawn wires hooked at both the ends and particularity designed to explore in the area of civil engineering applications. In this experimentation, fiber volume will vary from 0.5 to 1.5 % in addition to nano-silica.Properties of steel fiber are as follows in table no.02

Table 02: Physical Properties of Steel Fibers:

Sr. No.	Property	Values
1.	Diameter	0.75 mm
2.	Length of fiber	60 mm
3.	Appearance	Bright in clean wire
4.	Average aspect ratio	80
6.	Deformation	Hooked at both ends
7.	Tensile strength	1050 MPa
8.	Modulus of Elasticity	200 GPa
9.	Specific Gravity	7.8

Concrete mix design trials are made referring to “IS 10262” with a different variation in water cement ratio with steel fiber(SF) and Nano-silica(NS) for experimentation work. Control mix designed with the addition of superplasticizer to control workability of concrete to avoid the addition of water as its practically proven more of addition of water leads decrease in strength of concrete. In this investigation, three mixes were prepared and tested for 7 and 28 days with a 0.45 w/c ratio. Three mixes designated as MNSSF7.5/0.5 MIX NONOSILICA STEEL FIBER with 7.5% and 0.5% replacement by weight of cement similarly two more variations finalized based on previous literature available i.e MNSSF15/1.0 and MNSSF20/1.5 respectively. Concrete mix is prepared with the help of a concrete mixer of 1 cubic meter capacity to achieve a good quality of mixed concrete. Cube of size 100x100x100 mm was cast for 7 days and 28 days and tested as per IS 516 to find cube compressive strength as per specified period. For smooth demolding of cube application lubricant/oil is suggested to avoid any breakage of the specimen. After completion of curing age, concrete specimens s taken out of the curing tank and allow to keep the specimen in sun for drying purposes to avoid moisture content in concrete specimens at the time of testing on a CTM compression testing machine of 2000KN capacity.

3. Methods

The specimen used was cubes, beams, cylinder specimens, and cube specimens specially prepared to measure bond strength. Standard sizes of compression test specimens are Cube: 100 mm x100 mm x100 mm are used to calculate concrete cube compressive strength at 7 days and 28 days referring to IS 516 for testing three samples were cast to perform investigation for developing sustainable building construction material. Cubes were used to find the compressive strength.

3.1IS 516-1959 Hardened Concrete:

In this research work concrete cube compression test (CCCT)Nano Silica Steel Fiber Reinforced Concrete (NSSFRC) were performed as per IS guidelines on concrete cube samples. Setup for experimental investigation is as described below

3.2Concrete cube Compressive strength:

As per IS 516 guidelines concrete cube compressive strength can be estimated as per the experimental program and results are tabulated below with a graphical representation of variation observed in cube compressive strength concerning variation in fiber volume fraction and Nano-silica. Concrete cube compressive strength in 3rddegree polynomials in terms of Vfns derived from regression analysis in equations no.1 and 2.

7 Days: $f_{cu} = 0.325V_{fns}^{3} - 0.725V_{fns}^{2} - 3.56V_{fns} + 57.20$ (1)

28 Days: $f_{cu} = -0.241V_{fns}^{3} + 1.150V_{fns}^{2} + 3.091V_{fns} + 35.10$ (2)

Regression analysis is shown in above equation and analytical results tabulated in Table 02

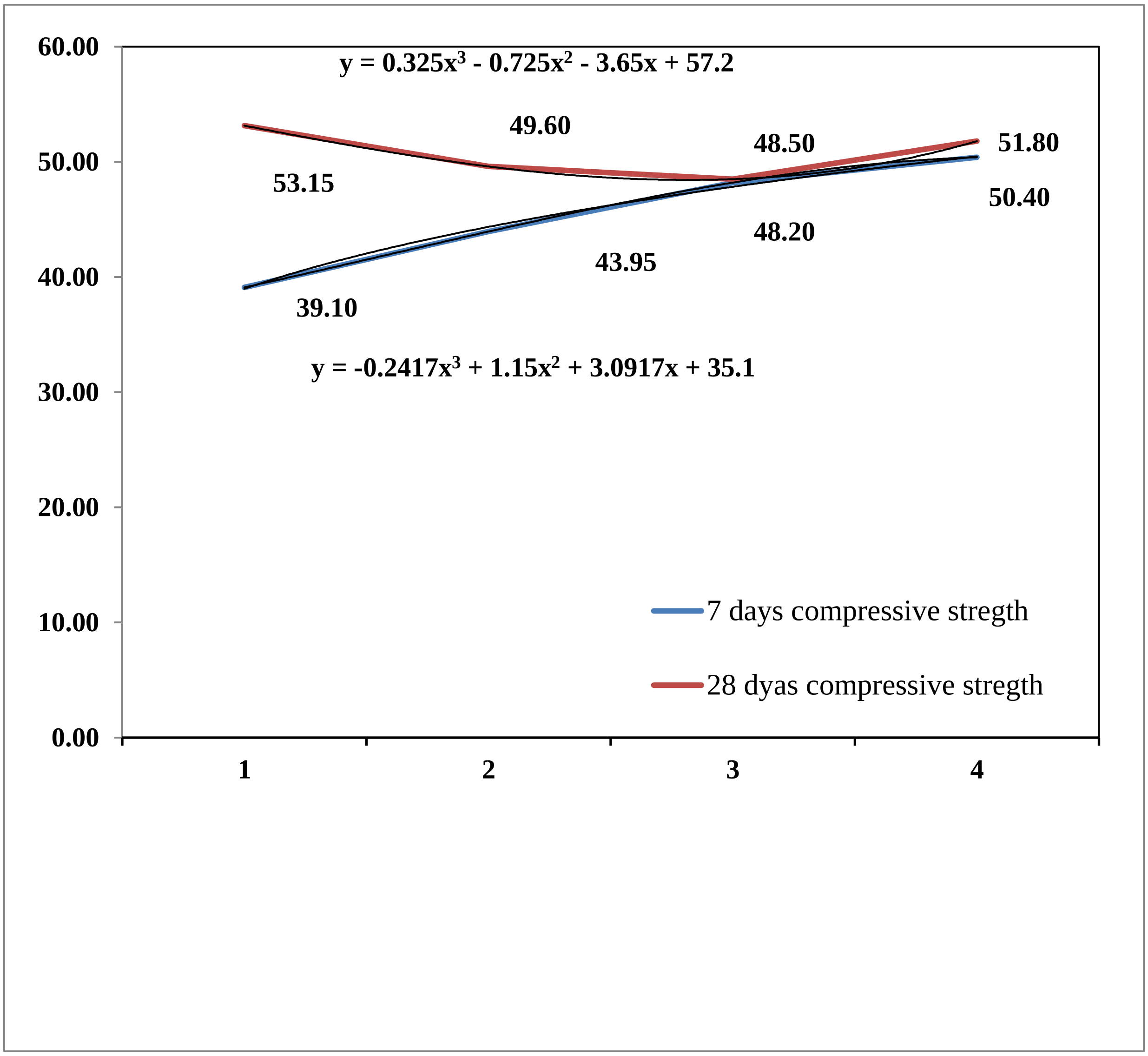
4. Results and discussion

In Compressive strength to calculate the optimal percentage of steel fiber and nano-silica to be added, the cycle of the compressive test is performed for various percentages of steel fiber and nano-silica. Cube samples were cast for M35 of concrete and were tested for 7 & 24 days on a compression testing machine as per I.S. 516-1959.

Table 02: Concrete cube compressive strength of normal and NSSFRC concretes, N/mm^2

Fibre	**Compressive Strength f_{cu}, MPa**		**% Compressive Strength w.r.to Control Concrete Mix**	
Content V_{fns} (%)	**07days**	**28 days**	**07days**	**28 days**

0.0	39.10	53.15	-	-
0.5	43.95	49.60	12.40	-6.68
1.0	48.20	48.50	23.27	-2.22
1.5	50.40	51.80	28.90	6.80



In general, satisfactory improvement at 7 days and 28 days in compressive strengths is observed with the inclusion of steel fibers with Nano silica in the nominal concrete. However, maximum gain in strength of concrete is found to depend upon the amount of fiber content.

The optimum fiber content to impart maximum gain in various strengths varies with the type of the strengths.

The variation in compressive strength at 7 and 28 days is mentioned in table no.02 The experimental results show that the tilt towards the positive side with the addition of fiber with Nano silica resulting an increase in mechanical properties of future concrete increased by 28% @ 7 days with a 1.5% of fiber volume fraction in compressive strength. Results from the experimental setup are showing good agreement with regression analysis.

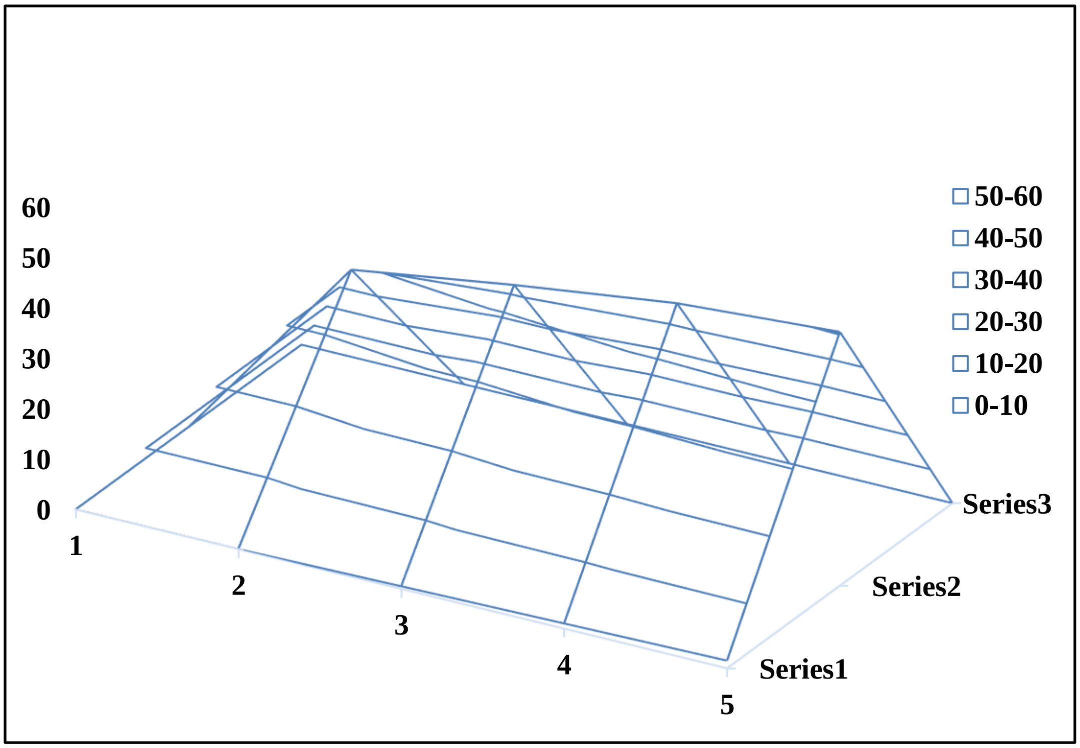


Figure 2a: Compressive Strength Area Variation at the age of 7 days with Respect to percentage Fibre Volume Fraction

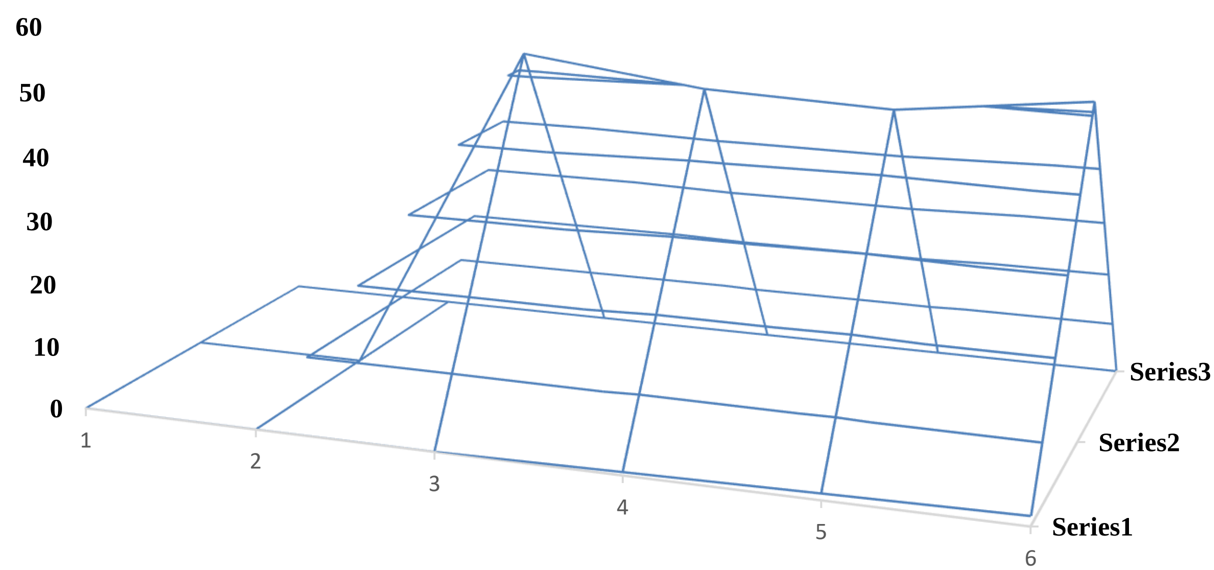


Figure 2b: Compressive Strength Area Variation at the age of 28 days with Respect to percentage Fibre Volume Fraction

An area chart is also studied in this research to showcase the experimental data which depicts curing time duration inclusion of different variations in fiber volume fraction at 7 and 28 days. Area Chart it is showing different series data and we have a different set of days 7 and 28 days and variation to showcase the relation of each set to the whole data which narrates area variation parameter, relating strength of concrete as an area of concrete reduce going hamper density of concrete, resulting low strength. From Area Chart one can easily understand the effect of variation of different volume fractions and mixes w.r.t the type of concrete. Here in the graph, it is clear that fiber volume fractions effects on area parameters of concrete.

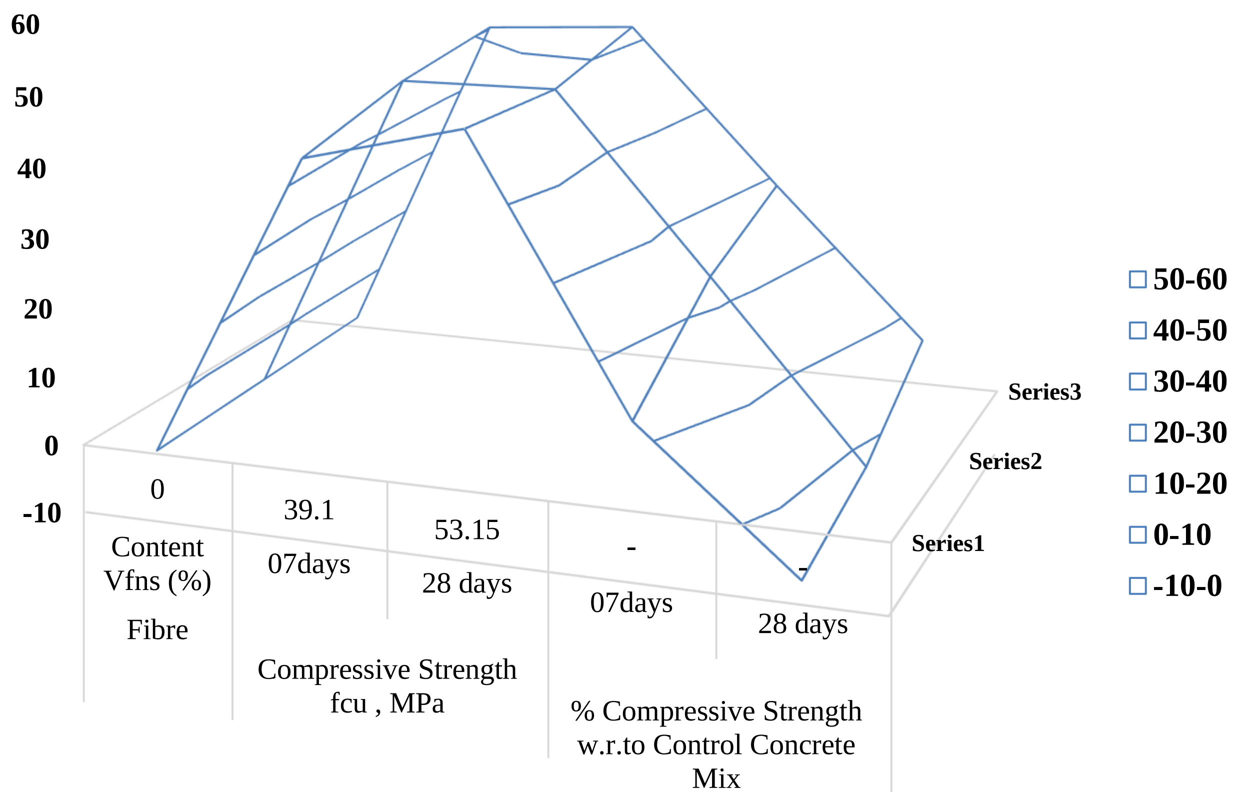


Figure 3: Compressive Strength Area Variation at the age of 7 & 28 days with Respect to percentage Fibre Volume Fraction

CONCLUSIONS

The performance of NSSFRC with different fiber volume fraction up to 1.5 % could be achieved in the field-appropriate mix. The maximum percentage (28 %) increase in compressive strength was achieved at 1.5% of fiber volume fractions. The empirical expressions have been established to predict the values of compressive strength; the Results predicted from these expressions are in good agreement with the experimental results in this investigation. The workability decreases as the fiber volume fraction increase. It was also found that the area concrete can affect the compressive strength of structural concrete at 7 and 28 days.

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