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"EXPERIMENT STUDY ON HIGH PERFORMANCE CONCRETE AS PARTIAL REPLACEMENT OF NANO-SILICA IN CEMENT"

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ABSTRACT: ***On the growing demand on the construction work, concrete work has been developing day by day on different study and research on concreting materials for the better performance towards the world. To improve the High Performance Concrete (HPC) the addition or replacement of different admixture ingredient are used such as silica-fume which is known as micro silica as well, nano-silica, rice ash husk, glass fiber, GGBS, metakolins, plasticizer, superplasticizer, etc..***
This project was carried out on the mineral admixture Nano-silica on the partial replacement of cement with conplast SP-430 superplasticizer by its optimum solution value. Nano-silica helps to strengthening the concrete which is used as cementitious nano sized materials. The reaction obtained with the addition of calcium silicate hydrate causes calcium leaching in water and leads to durability improvement. Thus, the experiment was carried out with M60 grade concrete mix design and the compressive test, split tensile test and flexural test were conducted to carry out the strength of the cubes, cylinder and beams respectively. The cubes were kept for curing and it was test on 7^{th}, 14^{th} and 28^{th} days respectively. Similarly, cylinder and beams were tested on 7^{th}, 14^{th} and 28^{th} days after the curing. The mineral admixture i.e, nano-silica was partially replaced on the variation of 0%, 1%, 2%, 3% respectively with optimum solution of conplast Sp-430 (superplasticizer).

Key words: Nano-silica, Conplast sp430, Compressive strength, Split tensile strength, Flexural strength, high performance concrete

1. INTRODUCTION

a) HIGH PERFORMANCE CONCRETE

Concrete technology has undergone every level of study in order to enhance the properties of concrete like durability and strength by introducing one of the methods HPC (i.e. high performance concrete). A concrete mixes, the process high strength and durability with comparison to ordinary concrete is called high performance concrete (HPC). The material include in high performance concrete are fly ash, silica fume and GGBS and any one of superplasticizer. The title high performance is vital because of its ingredients and proportions that are chosen specifically to obtain approximate properties for the uses in structure, to get low permeability and high strength. It is not a special type of concrete but it contains some mineral and chemical admixture to increase the strength, durability, workability qualities to very high range. The high performance concrete is also satisfying, however some results has done and already implies that concrete is vulnerable to deterioration, useless and if precautions are consider during design. The high performance is completely different and it gives high strength and can be used with different application for a given set of loads and for usage and exposers conditions, high performance concrete is decreases to obtain to optimize the performance characteristics. The uses of special ingredient is not necessary in high performance concrete that need to be careful while designing because of it has high advantages which makes increment in durability and produces less micro cracking.

b) NANO-SILICA:

The nanosilica refers very small size particles and nano technology is having attention because of its application to in materials. With an addition of nano-particles in concrete, the concrete is more effective when compare to micro size of particles and it increases the strength and durability. Some of the nano particles are $CaCO_3$, Fe_2O_3, TiO_2, Al_2O_3. The nano particles will act as nuclei to accelerate the hydration of cement. In the reduction of calcium leaching and refined of cement paste is the effect of nano silica. It controls of the C-S-H and it improves the performance of cementitious. The aggressive condition of calcium leaching process degrades. Investigation was done on the effect of CaOH addition on the properties of HPC i.e., cured at normal condition. It is concluded that with the addition of cement with FeO3 particles improve the split tensile and flexural strength of concrete and decreases the setting time. The use of nano-particles up to 2 % shows important in tensile strength. The compressive strength of concrete is increased with SiO2 particles phase. The new generation of clay of interest is nano clay because of its high performance composites.

c) OBJECTIVES OF THE PRESENT PROJECT:

The main objectives of this project are:

i. The objective of this project is to know the behavior of concrete with partial replacement of cement with Nano silica in High Performance Concrete in M60 grade.

ii. To determine optimum percentage of replacement of cement with Nano silica.
iii. To find the compressive strength, split tensile strength and flexural strength for 7 days, 14 days and 28 days.
iv. To compare the results with the replacement of Nano silica in High Performance Concrete.

2. EXPERIMENTAL PROGRAME:

Many research paper and journal studies were carried on the experiment title i.e., High Performance Concrete along with study of different mineral admixture and its properties and nanotechnology and its material were focused for consideration. Therefore, M60 mix design was prepared by IS 10262:2009. Multiple trail mixes was done for the selection of optimum dosage of conplast SP-430 superplasticizer as water reducing agent for the additional strength to the concrete. Hence, Nano-silica was chosen as mineral admixture for the experimental set up continuations with variation of 0%, 1%, 2%, 3% as partial replacement weight of cement for M60 mix design of concrete (IS. 10262:2009). Total 36+36+36 specimens of cubes, cylinder and beams was casted for compressive, split tensile and flexural test respectively on 7^{th}, 14^{th} ,28^{th} days respectively.

3. MATERIAL CHARACTERIZATION

a) Cement:

The Ordinary Portland Cement "**DECCAN**" of 53 grade is used and all the properties are specified from IS 12269-1987.

TABLE 1: PHYSICAL AND MECHANICAL PROPERTIES OF CEMENT

S. NO.	PARTICULARS OF TEST	TEST RESULTS
1.	Specific gravity	3.15
2.	Fineness	5.3
3.	Normal Consistency	32%
4.	Initial setting time	45 min.
5.	Final setting time	450 min.

b) Coarse Aggregate:

Coarse aggregate of 16mm and 20mm are selected by passing the aggregate through 12mm and 16mm sieves respectively. Angular shape particles of both the aggregate is taken. Specific gravity, fineness modulus and water absorption are different test to be conducted. It must be dust free and free from surface moisture.

TABLE 2: PROPERTIES OF COARSE AGGREGATE

S. NO.	PARTICULARS OF TEST	VALUE
1.	Specific gravity	2.62
2.	Fineness modulus	5.142
3	Flakiness Index 20 mm 10 mm	 12% 14%
4.	Elongation Index 20 mm 10 mm	 20% 28%

(c) Fine Aggregate:

In fine aggregate, natural sand is best one and it selected. From 4.75mm sieve sand is sieved and also washed to reduce the silt content. For natural sand, the water demand is slightly less, hence more preferable. The tests to be conducted on Natural sand are specific gravity, fineness modulus and water absorption.

TABLE 3: PROPERTIES OF FINE AGGREGATE

S. NO.	PARTICULARS OF TEST	VALUE
1.	Specific gravity	2.70
2.	Fineness modulus	3.87
3.	Zone	II

(d) Superplasticizer (Conplast Sp-430):

A high range water reducer is a chemical that is used as a mixture requiring a well dispersed particle suspension known as Superplasticizers. In order to avoid particle agglomeration, superplasticizers are used as dispersants and the flow characteristics of suspensions such as concrete applications are improved. The ratio of water and cement that does not

affect the workability of the mixture can be reduced and added to concrete or mortar to produce self-reinforced concrete and high-performance concrete.

Table 4: PROPERTIES OF CONPLAST SP430

Appearance	Brown Liquid
Specific Gravity	Typically 1.20 at 20C
Chloride Content	Nil to BS 5075
Air Entrainment	Typically less than 2% additional air is entrained at normal dosages.
Alkali Content	Typically less than 72.0g Na2O equivalent/litre of admixture. A fact sheet on this subject is available.

(e)Water:

For mixing and curing of concrete portable water is used which can be available in laboratory. Unwanted substances and chemical oxides free containing water must be used.

TABLE 5: PHYSICAL PROPERTIES OF WATER

S.No.	Property	Value
1	pH	7.1
2	Taste	Agreeable
3	Appearance	clear
4	Turbidity	7.51

(f)Nano-silica:

A new pozzolanic material widely found in the form of water emulsion of colloidal silica is Nano-silica. Because of high content of amorphous silica (>99%) and the reduced size of its spherical particles of order 5-10*nm* it is better pozzolanic material in potential. ASTRRA CHEMICALS of Chennai is a distributer company from where nano silica was brought.

TABLE 6: TEST CERTIFICATE OF NANO-SILICA BY ASTRA CHEMICALS

TEST ITEM	STANDARD REQUIREMENTS	TEST RESULTS
SPECIFIC SURFACE AREA (M2/G)	200 + 20	202
PH VALUE	3.7 – 4.5	4. 12
LOSS ON DRYING @ 105 DEG.C (5)	< 1. 5	0. 47
LOSS ON IGNITION @ 1000 DEG.C (%)	< 2.0	0.66
SIEVE RESIDUE (5)	< 0. 04	0. 02
TAMPED DENSITY g/L	40 – 60	44
SiO2 CONTENT (%)	> 99. 8	99. 88
CARBON CONTENT (%)	< 0. 15	0. 06

CHLORIDE CONTENT (%)	< 0. 0202	0. 009
Al2O3	< 0. 03	0. 005
TiO2	< 0. 02	0. 004
Fe2O3	< 0. 003	0. 001

4. TESTS, GRAPHS & RESULTS.

i. Compressive strength trails for optimum conplast SP430: A total of 42 cubes were cast for the seven mixes. i.e for each mix 6 cubes were prepared. Testing of specimens was done at 7 and 28 days at the rate of three cubes for each mix on that particular day. The average value of the 3 specimens is reported as the strength at that particular age
Result: 1.0 % value was selected as Conplast Sp430 as optimum dosage.

TABLE 7: COMPRESSIVE STRENGTH TRAILS FOR OPTIMUM CONPLAST SP430

Percentage Conplast SP430	7 Days N/mm^2	28 Days N/mm^2
0.8	42.9	53.18
0.9	43.9	59.16
1.0	47.34	69.13
1.1	46.29	63.47
1.2	41.39	62.13
1.3	37.68	57.36
1.4	31.78	51.14

ii. Compressive Strength Test:
The compressive strength of the concrete was casted on 150 x 150 x 150 mm cubes. The average value of the 3 specimens is reported as the strength at that particular age.

TABLE 8: COMPRESSIVE STRENGTH TEST RESULT

S.No.	Nano-silica in partial replacement	Average compressive strength (N/mm^2)		
	(%)	7Days	14Days	28Days
1	0%	46.38	61.97	68.68
2	1%	48.76	63.053	70.006
3	**2%**	**49.81**	**64.14**	**71.85**
4	3%	42.67	59.033	61.873

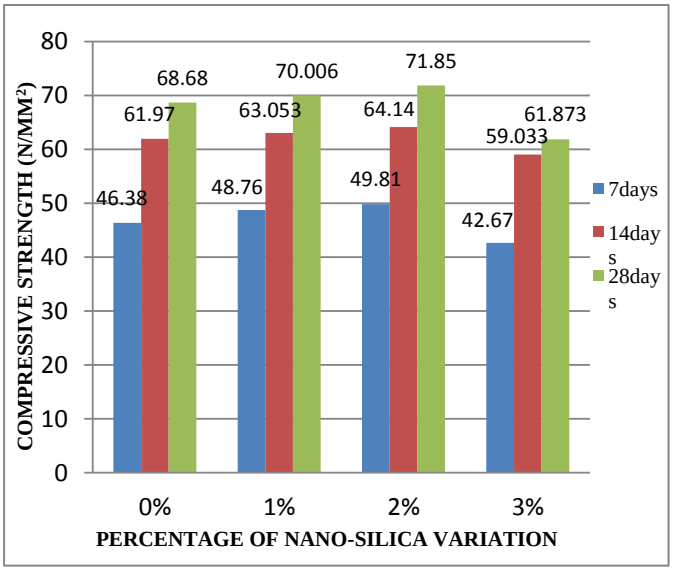

Figure1: Graphical representation of Compressive strength.

iii. Split Tensile Strength:

Standard cylinder specimens of length 300 mm and diameter 150 mm were tested for split tensile strength. The average value of the 3 specimens is reported as the strength at that particular age.

TABLE 9: SPLIT TENSILE STRENGTH TEST RESULTS

S.No.	Nano-silica in partial replacement	Average split tensile strength (N/mm^2)		
	(%)	7Days	14Days	28Days
1	0%	3.27	3.78	3.863
2	1%	3.58	3.99	4.19
3	**2%**	**4.04**	**4.29**	**4.32**
4	3%	2.92	3.11	3.806

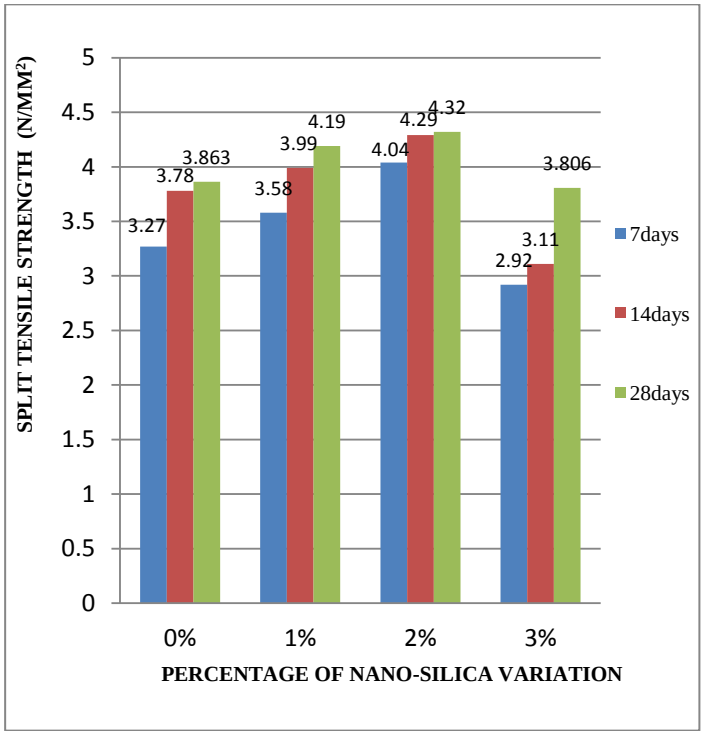

Figure2:Graphical representation of split tensile strength .

iv. Flexural Strength Test:

The Flexural strength of the concrete was done on 100 x 100 x 500 mm Beams. The average value of the 3 specimens is reported as the strength at that particular age.

Table 10: FLEXURAL STRENGTH TEST RESULTS

S.No.	Nano-silica in partial replacement	Average flexural strength (N/mm^2)		
	(%)	7Days	14Days	28Days
1	0%	3.92	4.12	5.46
2	1%	4.11	4.386	5.51
3	**2%**	**4.29**	**4.96**	**5.92**
4	3%	3.91	4.09	4.973

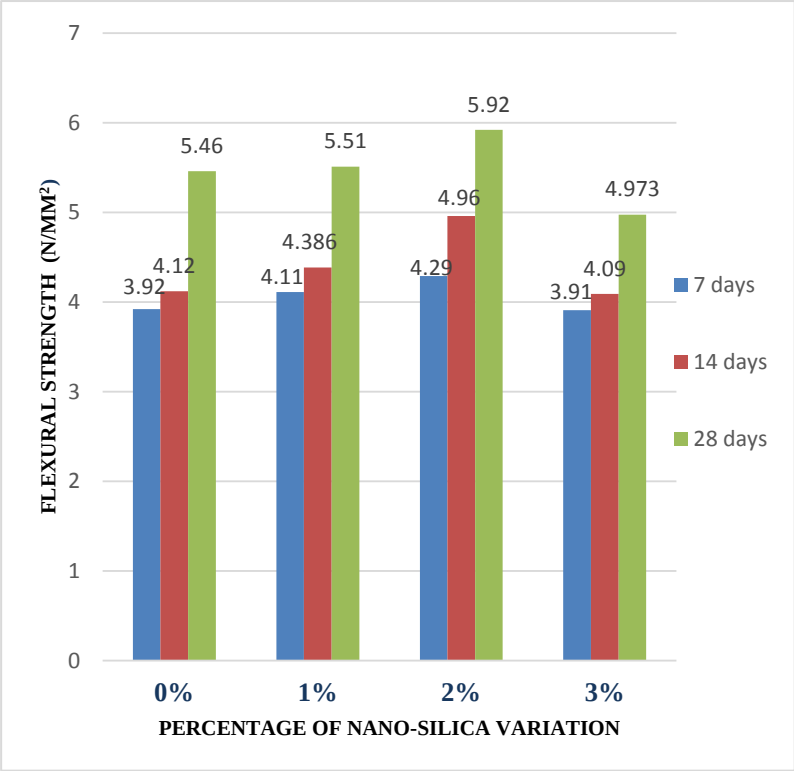

Figure3. Graphical representation of flexural strength.

5. CONCLUSION

All the experimental data shows that the mixing of Nano-Silica in concrete is far better in physical and mechanical properties than the normal concrete. So, it can play a vital role in construction field in coming days.
According to experiment and its result, following conclusion has been stated:

i. At 2% of Nano-silica partially replaced with cement of 0.3 water cement ratio, yields the better compressive strength results. We know that pozzolanic materials increases the compressive strength of concrete at optimum proportions replaced with cement because of, siliceous material that develops any hydraulic cementitious properties in the presence of lime is added into OPC cement which reacts with free lime and convert in to calcium silicate hydrate which gives strength to concrete.
ii. Partial replacement of 2% of nano-silica with cement, the compressive strength of concrete for 7 days is 49.81 N/mm^2, for 14 days is 64.14 N/mm2 and 28 days is 71.85 N/mm^2 which is more than the conventional mixes i.e. increases by, 3.43 N/mm^2 for 7 days, 2.17 N/mm^2 for 14 days and 3.17 N/mm^2 for 28 days than the conventional mixes respectively.
iii. Partial replacement of 2% Nano-silica with cement, the split tensile strength of concrete for 7 days is 4.04 N/mm^2, for 14 days is 4.29 N/mm^2 and 28 days is 4.32 N/mm^2 which is more than the conventional mixes i.e. increases by, 0.77 N/mm^2 for 7 days, 0.51 N/mm^2 for 14 days and 0.457 N/mm^2 for 28 days than the conventional mixes respectively.
iv. Partial replacement of 2% Nano-silica with cement, the flexural strength of concrete for 7 days is 4.29 N/mm^2, for 14 days is 4.96 N/mm^2 and 28 days is 5.92 N/mm^2 which is more than the conventional mixes i.e. increases by, 0.37 N/mm^2 for 7 days, 0.84 N/mm^2 for 14 days and 0.46 N/mm^2 for 28 days than the conventional mixes respectively.
v. Better cost economic due to its strength gaining properties which is highly favorable life cost economic.
vi. Nano-silica particles are finer which help to better finishing of concrete.

6. SCOPE FOR FUTURE WORK

In regard to the project **"**Experiment study on High Performance Concrete (HPC) on partial replacement of nano-silica in cement**",** following things can be taken in consideration in the future:

i. Curing periods can be extended for further 56 and 90 days because Silica strength increases with increase in age of concrete.
ii. Effective curing methods can be used with the help of different admixtures which could reduce shrinkage and creep and also to maintain good quality control throughout the precast concrete element.
iii. Similarly, different water cement ratio other than applied in this project cans be tested.
iv. There is a scope to use other pozzolanic materials such as Metakaolin, Ceramic powder or Rice husk ash.

REFRENCES

[1] SudarsanRao. Hunchate, Sashidhar. Chandupalle, Vaishali G. Ghorpode and VenkataReddy T.C. (2014): Study on "Mix Design of High Performance Concrete Using Silica Fume and Superplasticizer". Published by International Journal of Innovative Research in Science, Engineering and Technology .Vol. 3, Issue -3, March 2014.

[2] Jugal A. Mistry, Dr.Indrajit N. Patel, Mrs.Jagruti Shah(2015): Study on "EFFECT OF NANO SILICA ON COMPRESSIVE STRENGTH OF HIGH VOLUME FLYASH CONCRETE". Published by: International Journal of Advance Engineering and Research Development Volume2, Issue 5, May -2015.

[3] F.MohamedYasir Arafath, S.Ajeeth Peter Francisco, S.Vinoth Bharathi, M.Kirubakaran, N.Elakkiyarajan (2018): Study on "Investigation of Nanosilica in Enhancing the Strength of Cement Concrete". Published by International Journal of Innovative Research in Science, Engineering and Technology. Certified Organization Volume 7, Special Issue 5th April 2018.

[4] Rituraj.S. Rathore and Arpit Chawda (2016): Study on "Partial Replacement of OPC by Silica Fume with M60 Grade Concrete". Published by: KrishiSanskriti Volume 3, Issue 8; July-September, 2016.

[5] Fayaz. Shaik, MalavikaChakravarthy P.G.(2016): Study on "Study on Strength Characteristics for M 60 Grade Concrete Using Fly Ash, Silica Fume, Metakaolin, and Steel Fibers". Published by : (IJLTEMAS). Volume V, Issue XI, November 2016

[6] Devananda Reddy, G.R.Krishnamurthy (2015): Study on "Experimental Study on Mechanical Properties of High Strength Concrete for M60 Grade Concrete". Published by: (IJSR).

[7] S. Suresh Sankaranarayannan, J. Revathi Jagadesan (2016): Study on "Comparison of High Performance Fly Ash Concrete Using Nano Silica Fume on Different Mixes". Published on 7 June 2016 @ authors and Scientific Research Publishing Inc.

[8] Susheel S M, Sanjith J and Ranjith A (2015): Study on "Effect of Nano Silica fume on Concrete". Published by: IJISET, Vol. 3 Issue 6, June 2016.