IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

AN EXPERIMENTAL STUDY ON USE OF NANO SILICA POWDER AS PARTIAL REPLACEMENT OF CEMENT IN CEMENT CONCRETE

Ambuj Grover[1], Mr. Rakesh Kumar Pandey[2], Mr. Abhishek Singh[3]

[1]Student, M. Tech (Structural Engineering), Amity University Raipur Chhattisgarh

[2]HOD, Dept. of Civil Engineering, Amity University Raipur Chhattisgarh

[3]Assistant Professor, Dept. of Civil Engineering, Amity University Raipur Chhattisgarh

Abstract: Nanotechnology is emerging as the most active research field which is widely being used in all the industries now days all over the world. Since concrete is most common material used in construction industry it is important to advance its strength and workability characteristics. By addition of Nano silica powder it has shown immense improvement in concrete characteristics like strength and workability. The use of Nano silica powder in concrete as a partial replacement of cement not only protects the environmental pollution by decreasing the waste material and CO_2 emission but also save the resources and energy. Here we studied the effect of Nano-silica powder on various properties of concrete like compressive strength and split tensile strength by replacing it with cement in various percentages of Nano silica powder. Test samples S1, S2, S3, S4, S5, S6, S7 were prepared by using Nano-Silica powder as a partial replacement for cement in different ranges of 0%, 0.5%, 1%, 1.5%, 2%, 2.5% and 3% by weight of cement for M20 mix of ratio 1:1.5:3(Cement : sand : aggregate). Forty two concrete cubes and cylinders were casted on which different Laboratory tests were conducted to determine the Workability, Compaction Factor, Compressive Strength and Split Tensile Strength of Nano-silica concrete at the age of 7 and 28 days. Results designate that by using small amount of Nano silica powder increases the strength and workability properties of concrete in comparison with conventional concrete.

Index Terms **- Nanotechnology, Nano Silica Powder, Compressive Strength, Workability, Compaction Factor, Split Tensile Strength**

1. INTRODUCTION

In recent few years Nanotechnology is widely used all over the world in every field now a days in construction field also. Nano technology is a technology in which things are made as small as possible. In our study we used Nano material i.e.; 'Nano silica powder' which is one of the finest Nano material used most commonly in ceramic industry. Nano silica powder is high pozzolanic material obtained from olivine rock. The size of Nano silica powder is thousand times smaller than that of usual size of cement particles. Nano silica powder reduces the setting time of cement and increases the compressive strength and split tensile strength of concrete. As concrete is one of the most widely used material in construction industry it is important to improve its quality. So in our study by adding Nano silica powder as a partial replacement of cement has shown major improvement in concrete as compare to conventional concrete.

1.1 NANO SILICA POWDER

Nano silica powder is a very fine material which is obtained by mixing sulphuric acid with olivine rock. It is one of the key material which is most commonly used now a days in ceramic industry. It is thousand times smaller than usual a cement particle. It contains 99.8 % SiO_2. It is white in colour as shown in figure below.

Figure 1 - Nano Silica Powder

2. MATERIAL AND ITS PROPERTIES

Various materials used in our study are cement, sand, water, aggregate and Nano Silica Powder. Properties of these materials are determined by different lab tests which are tabulated below-

2.1 CEMENT

Cement for our study is purchased from local shop in Raipur district. It is Ordinary Portland Cement of Ultratech brand with compressive strength of 53 N/mm^2. Test for soundness, consistency, initial and final setting time and specific gravity are performed in lab. Test results are as follows –

Table 1- Physical properties of Cement

Parameter	Value
Normal consistency (%)	29
Specific gravity, G_C	3.15
Initial /Final setting time (minutes)	43/365
Soundness by Le-Chatelier expansion (mm)	3

Table 2- Chemical composition of Cement

CaO	SiO_2	AlO_3	Fe_2O_3	Mg O	K_2O	SO_3	P_2O_5	LOI	LSF
64.26	21.07	5.54	5.16	0.86	0.37	0.72	0.33	1.54	0.925

2.2 SAND

Sand for our study is obtained from Samoda River near Arang block, Raipur district, Chhattisgarh. Test for specific gravity and fineness modulus are performed in lab for sand. Test results are as follows –

Table 3- Sieve Analysis of Fine Aggregate

I.S. Sieve size	Percentage passing		Remark
	As per test	IS requirement for Zone III	
10mm	100	100	Falling in zone III
4.75mm	98.57	100-90	
2.36mm	83.46	85-100	
1.18mm	74.56	75-100	
600µ	68.23	60-79	
300µ	34.38	12-40	
150µ	8.19	0-10	
75µ	0.80%	Max 15	

Table 4- Physical Properties of Fine Aggregate

Physical properties of fine aggregate	**Results**
Specific gravity	2.65
Fineness modulus	2.81

2.3 AGGREGATE

Aggregate for our study is obtained from Budera Mines near Budera Village, Raipur district, Chhattisgarh. Test for specific gravity and fineness modulus are performed in lab for sand. Test results are as follows –

Table 5- Properties of Coarse Aggregate

Physical properties of coarse aggregate	Results
Specific gravity	2.77
Fineness modulus	6.72
Shape	Angular
Size	20 mm

2.4 NANO SILICA POWDER

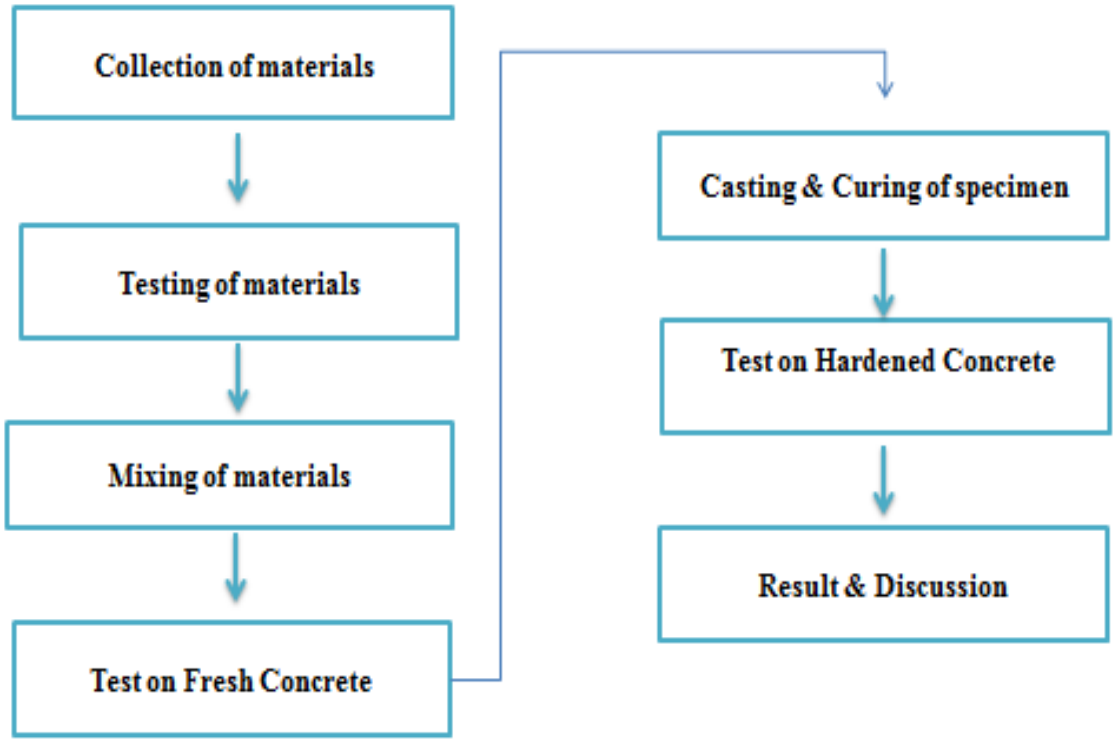
Nano Silica Powder for our study is purchased online from www.indiamart.com. Its Properties are shown below -

Table 6- Physical Characteristics of Nano Silica

S. No.	Characteristics	Result
1.	Specific surface area (M^2/GM)	200
2.	PH value	3.7 to 4.5
3.	Loss on drying @ 105^0c (%)	< 1.5%
4.	Loss on ignition @ 1000^0c (%)	< 2
5.	Sieve residue (%)	< 0.04

3. METHODOLOGY

The methodology adopted has been represented by flowchart:



3.1 MIXING OF MATERIALS

Concrete mixing is done using hand mix. First cement, sand and aggregate are taken in proportion 1:1.5:3 and mixed with nano silica powder in different percentages i.e. 0%, 0.5%, 1%, 1.5%, 2%, 2.5% and 3% by replacing it with cement respectively. By which different mixes were formed named as S1, S2, S3, S4, S5, S6 and S7 then cement is mixed in required proportion by shovels. After this water is added to the different mixes to form concrete of required consistency by keeping water cement ratio of 0.40.

3.2 TESTS ON FRESH CONCRETE

For testing fresh concrete properties tests like slump test and compaction factor test are performed. These tests determine the workability and compaction factor of concrete.

3.3 CASTING AND CURING OF SPECIMEN

42 Cubes of size (150×150×150) mm and 42 Cylinders of size (150×300) mm were casted and tests were conducted to study the strength characteristics of hardened concrete of different test samples S1, S2, S3, S4, S5, S6 and S7. Curing is the process of keeping the concrete moist enough, so that the hydration of cement can be completed until the desired properties are developed. The specimens are taken out of the mould after 24hrs and are then submerged into the water tank for curing period of 7 and 28 days.

3.4 TESTS ON HARDENED CONCRETE

Since the strength of concrete is related to the structure of hardened cement paste the following tests that have been performed on hardened concrete for assessing the strength of concrete. These tests are Compressive strength test and Split tensile strength test.

3.4.1 COMPRESSIVE STRENGTH TEST

As per IS Code for each mix 3 cubes should be casted for checking the compressive strength of concrete so after the desired curing period, the compressive strength of the specimen is determined. So in total forty two cubes each of size 15cm X 15cm X 15cm were tested by compressive testing machine out of which 21 cubes were tested after 7 days and 21 cubes were tested after 28-days.

Compressive strength= Load/Cross sectional area

Figure 2- Compressive Strength Test

3.4.2 SPLIT TENSILE STRENGTH TEST

As per IS Code for each mix 3 numbers of cylindrical specimens of size (15cmX30cm) were casted and after the desired curing period, the split tensile strength of the cylinder is determined. So in total forty two cylinders were tested out of which 21 cylinders were tested after 7 days and 21 cylinders were tested after 28-days.

Split tensile strength = $2P / \pi DL$,

Where P = Applied load**,** L = Length of the specimen,

D = diameter of the specimen.

Figure 3- Split Tensile Strength Test

4. TEST RESULTS

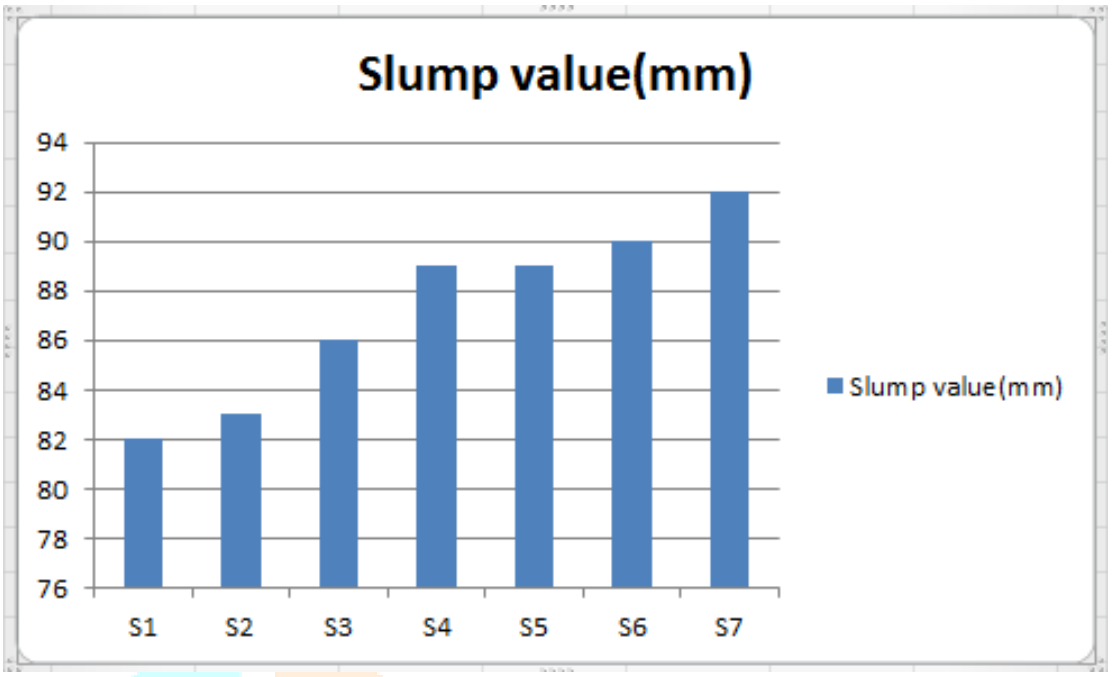
This chapter is concerned with the presentation of results of the experiments carried out towards the objective of the project. It includes results from Slump test, Compaction factor test, Compressive Strength Test and Split TensileStrength.

4.1 SLUMP TEST RESULTS

Table7- Slump Test values:

Mix	Percentage of cement replaced with nano silica powder	Slump value(mm)
S1	0 %	82
S2	0.5 %	83
S3	1 %	86
S4	1.5 %	89
S5	2 %	89
S6	2.5 %	90
S7	3 %	92

Figure 4 – Graph of Slump value (mm).



4.2 COMPACTION FACTOR TEST RESULTS

Table 8- Compaction Test values

Mix	Percentage of cement replaced with nano silica powder	Partially Compacted Concrete (W_1)Kg	Fully Compacted Concrete (W_2)Kg	Empty Cylinder (W)Kg	Compaction Factor(W_1-W) / (W_2-W)
S1	0 %	14.5	17.2	4.6	0.79
S2	0.5 %	14.8	17.5	4.6	0.79
S3	1 %	15.2	17.6	4.6	0.82
S4	1.5 %	15.3	17.6	4.6	0.82
S5	2 %	15.8	17.8	4.6	0.85
S6	2.5 %	16.4	17.9	4.6	0.89
S7	3 %	16.9	17.9	4.6	0.92

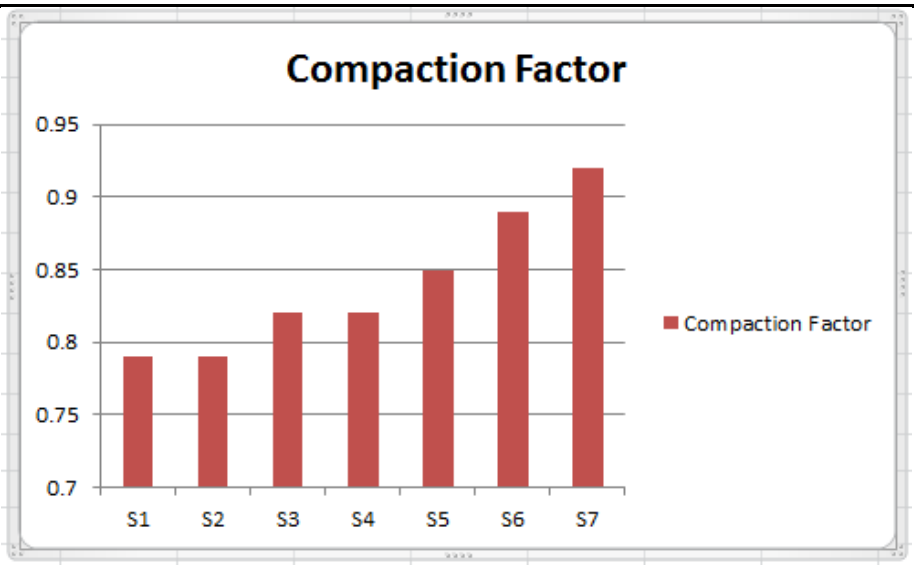


Figure 5 – Graph of Compaction factor test.

4.3 COMPRESSIVE STRENGTH TEST RESULTS

Table-9 Compressive Strength Test values

Mix	Percentage of cement replaced with nano silica powder	w/c	7 days f_{ck}	28 days f_{ck}
S1-1	0 %	0.4	13.2	22.5
S1-2	0 %	0.4	13.8	23.1
S1-3	0 %	0.4	13.5	23.4
S2-1	0.5%	0.4	16.5	23.5
S2-2	0.5%	0.4	17.2	24.2
S2-3	0.5%	0.4	16.9	24.8
S3-1	1%	0.4	18.2	25.3
S3-2	1%	0.4	18.75	26.2
S3-3	1%	0.4	17.8	25.8
S4-1	1.5%	0.4	18.9	28.2
S4-2	1.5%	0.4	18.5	28.6
S4-3	1.5%	0.4	19.1	30.1
S5-1	2%	0.4	20.6	31.5
S5-2	2%	0.4	21.7	30.5
S5-3	2%	0.4	21.4	30.2
S6-1	2.5%	0.4	23.5	32.2
S6-2	2.5%	0.4	22.9	33.5
S6-3	2.5%	0.4	23.8	33.8
S7-1	3%	0.4	21.9	29.4
S7-2	3%	0.4	22.5	30.25
S7-3	3%	0.4	22.3	30.4

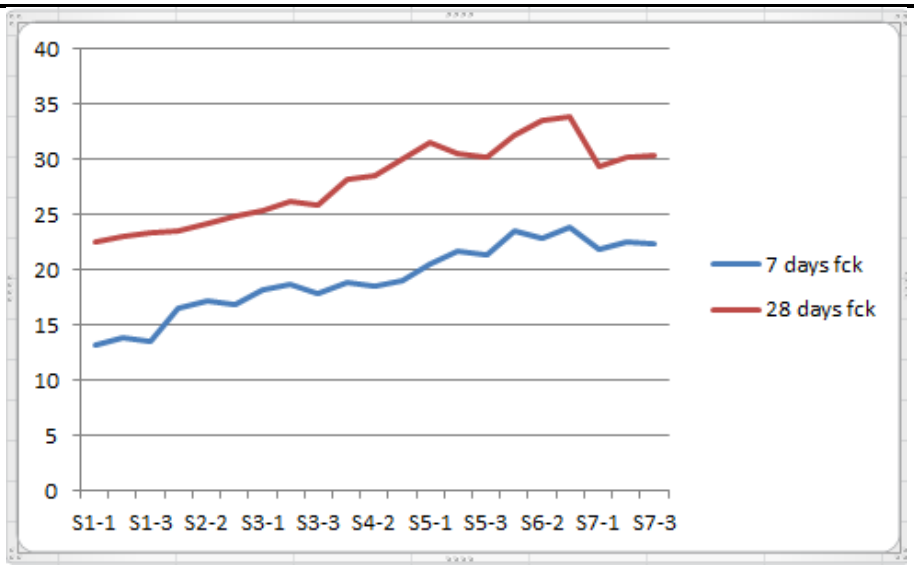


Figure 6 – Graph for compressive strength test.

4.4 SPLIT TENSILE STRENGTH TEST RESULTS

Table-10 Split Tensile Strength Test values

Mix	Percentage of cement replaced with nano silica powder	w/c	7 days tensile strength	28 days tensile strength
S1-1	0 %	0.4	1.73	3.13
S1-2	0 %	0.4	1.69	3.15
S1-3	0 %	0.4	1.74	3.09
S2-1	0.5%	0.4	1.92	3.22
S2-2	0.5%	0.4	1.95	3.28
S2-3	0.5%	0.4	2.08	3.34
S3-1	1%	0.4	2.12	3.45
S3-2	1%	0.4	2.06	3.36
S3-3	1%	0.4	2.22	3.28
S4-1	1.5%	0.4	2.26	3.55
S4-2	1.5%	0.4	2.15	3.59
S4-3	1.5%	0.4	2.22	3.64
S5-1	2%	0.4	2.57	3.72
S5-2	2%	0.4	2.65	3.81
S5-3	2%	0.4	2.54	3.75
S6-1	2.5%	0.4	2.74	3.82
S6-2	2.5%	0.4	2.82	3.90
S6-3	2.5%	0.4	2.85	3.89
S7-1	3%	0.4	2.62	3.48
S7-2	3%	0.4	2.55	3.52
S7-3	3%	0.4	2.58	3.59

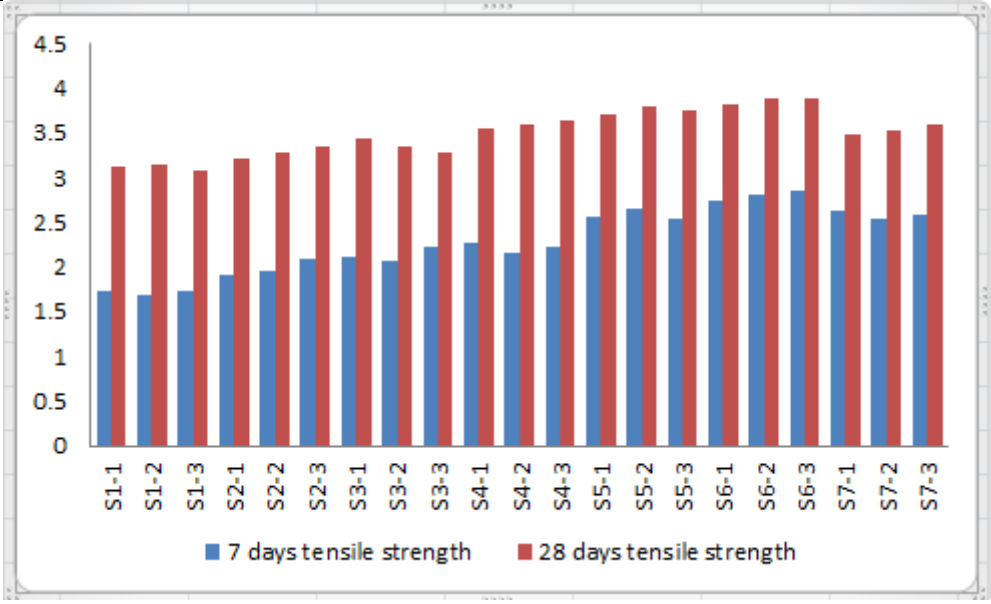


Figure 7– Graph for Split tensile strength test.

5. CONCLUSION

1. Replacement of 2.5% of cement with nano silica powder shows increase in strength of concrete as compare to normal concrete. The compressive strength of concrete after 7 days and 28 days from table 9 indicates that for mix S6 it is maximum i.e. 23.4MPa and 33.16MPa. So it can be concluded that replacing 2.5% of cement with nano silica powder increases the compressive strength of concrete upto 40%.

2. The split tensile strength of concrete after 7 days and 28 days from table 10 indicates that for mix S6 it is maximum i.e. 2.80 MPa and 3.87 MPa. So it can be concluded that replacing 2.5% of cement with nano silica powder increases the split tensile strength of concrete upto 37.5%. So it can be concluded that just by replacing 2.5% of cement with nano silica powder will result in increase in strength and durability characteristics of concrete.

3. On addition of Nano Silca powder there is a substantial increase in the early-age strength of concrete compared to the 28 days increase in strength.

4. With addition of small amount of Nano-silica powder will give considerable increase in strength and mechanical properties of concrete.

6. REFRENCES

1. R. Sakthivel and Dr.N.Balasundaram (2016) "Experimental Investigation on Behavior of Nano Concrete " International Journal of Civil Engineering and Technology , Volume 7, Issue 2, March April 2016, pp. 315-320.

2.Rutuja Mininath Sarade, Suraj Ramesh Shinde, Rohan Kantilal Wayase, Namdev Bapu Rajguru, Dr. P. D. Nemade (2017) "Effect of Nano Silica on Compressive Strength of Concrete" International Journal for Scientific Research & Development, Volume 5, Issue 04, 2017, ISSN: 2321-0613.

3.Mani.M, Dr. G. Nandini Devi (2017) " Study on Behavior of Nano Concrete " International Journal of Emerging Trends & Technology in Computer Science, Volume 6, Issue 5, September October 2017, ISSN: 2278-6856.

4.Jitendra Patil, Dr. Umesh Pendharkar (2016) " Study of Effect of Nanomaterials as Cement Replacement on Physical Properties of Concrete" International Research Journal of Engineering and Technology, Volume: 03, Issue: 01, Jan 2016, e-ISSN: 2395-0056, p- ISSN: 2395-0072.

5.Yuvaraj, Shanmugasundaram, Dinesh Nagarajan, Karthic Ramachandran, Dr. Suji Mohankumar (2012) “Experimental Study on the Influence of Nano silica in the Strength and Durability of Concrete.”, pp. 4246.

6.IS:456-2000, Indian Standard "Plain and Reinforced Concrete" Code of Practice (Fourth Revision), Bureau of Indian Standards, New Delhi 110002.

7.IS:2386-1963 (Part-III). Indian Standard " Methods of Test for aggregates for concrete Part III specific gravity, density, voids, absorption and bulking", Bureau of Indian Standards, New Delhi 110002.

8.IS: 516-1959, Indian Standard " Methods of Testing for Strength of Concrete", Code of Practice, Bureau of Indian Standards, New Delhi 110002.

9.M.S.Shetty , "Concrete Technology", S. Chand and Company ltd, New Delhi.

10.Ambuj Grover, Strength & Durability Characteristics of Concrete by using Nano Silica, HTL Journal Volume 26, Issue 12, 2020