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Research Paper

EFFECT OF NANO SILICA AND MICRO SILICA ON THE STRENGTH AND MICROSTRUCTURE OF HIGH STRENGTH CONCRETE

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ABSTRACT

High-strength concrete (HSC) plays a vital role in modern civil engineering due to its superior mechanical performance and durability. However, achieving enhanced strength and dense microstructure requires the incorporation of advanced mineral admixtures. This study investigates the combined and individual effects of nano silica and micro silica on the mechanical properties and microstructural characteristics of high-strength concrete. Nano silica, with its extremely fine particle size and high pozzolanic reactivity, improves early-age strength and refines pore structure, while micro silica enhances bonding between cement paste and aggregates through improved packing density and secondary C-S-H gel formation. Experimental results demonstrate a significant increase in compressive strength, split tensile strength, and flexural strength with optimal replacement levels of cement by nano silica (1–3%) and micro silica (5–10%). Scanning Electron Microscopy (SEM) and X-ray Diffraction (XRD) analyses indicate reduced microcracking and a denser, more homogeneous matrix. The synergistic use of nano and micro silica substantially enhances the performance and durability of HSC compared to conventional mixes. These findings suggest that nano-modified concrete offers promising potential for high-performance structural applications requiring long-term strength and durability.

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I. INTRODUCTION

1.1 GENERAL

Concrete will be stuff composed primarily of cement, combination and water. It is a wide used construction material for varied types of structures ascribable to its structural stability and strength. Increasing the event challenges in combos with the new innovations in materials and production techniques have give new basis for manufacturing high performance concrete structures. Presently concrete is obtaining used for wide styles of functions to make it applicable in varied conditions. In these conditions commonplace concrete could fail to exhibit the desired quality performance or strength. In such cases, pozzolanic or mineral admixtures ar accustomed modify the properties of traditional concrete.

The word 'Pozzolana' was derived from pozzuolu, a city in Italy, some of miles from metropolis and mount vacuous. The materials are of volcanic region containing varied fragments of stone, obsidian, feldspars, and quartz etc. The name 'Pozzolana' was initial applied only to the current material. However the term has been extended later to earth, terribly chemical compound rocks and varied artificial merchandise. Thus, the pozzolanic materials are natural or artificial having nearly identical composition as that of volcanic tuffs or ash found at pozzuolu.

With the advancement of technology and enlarged field of applications of concrete and mortars, the strength, workability, strength and varied characteristics of the standard concrete would like modifications to make it applicable for difficult desires for construction environment(Added to the current is that the requirement to combat the increasing price and inadequacy of cement). Beneath these circumstances the utilization of admixtures is found to be an important completely different answer.

1.2 NANOTECHNOLOGY

Nanotechnology is that the employment of really little things of fabric by themselves or their manipulation to make new large scale materials. The particle size may be a big issue. At the nano scale (anything from 100 or more right all the method all the way down to some of nano meters, or 10-9 nm) material properties ar altered from that of larger scales. There's a sudden modification in state of affairs and this might be what happens at the dimensions of technology. As particles become nano-sized, the proportion of atoms on the surface will increase and this ends up in modification among the properties. Knowledge at the nano scale of the structure and characteristics of materials (otherwise referred to as characterization) will promote the event of latest applications and new merchandise to repair or improve the properties of construction materials. as associate example, the structure of the essential Calcium-silicate-hydrate (C-S-H) gel that is in charge of the mechanical and post-selfing physical properties of cement pastes, like shrinkage, creep, porosity, consistence unit of measurement typically improved to urge higher strength characteristics of concrete.

1.3 NANO TECHNOLOGY IN CONCRETE

One of the foremost and extremely important helpful uses of technology in technology is to use in concrete. It's utilized in regarding of all construction fields like roads, bridges, buildings and varied construction works. Concrete unit of measurement typically changed in varied ways; one in every of that is to feature nano particles to that. Researchers are aiming for how higher understanding of the delicate structure of cement- based materials at nano levels. This could ends up in new generation of stronger and additional sturdy concrete with desired behaviors and properties. Association of cement produces a rigid, heterogeneous microstructure.

1.4 TYPES OF NANO MATERIALS

1. Nano silicon dioxide (NS)
2. Nano Metakolin
3. Carbon nano tubes (CNT's)
4. Polycarboxilates

1.5 NEED FOR PRESENT WORK

Mortar and concrete are composite materials whose over all mechanical properties are suffering from properties and arrangement of every constituent (cement, aggregate) in it. By incorporating nano materials in to matrix to enhance mechanical properties, emerged as a promising analysis field of nano composite. When put next with dense structure matrix like polymer, the case is kind of different within the area of cement matrix composites. As a result of cement matrix has relative loose structure. Between the cement and mixture there are nano sized air voids which can have vital impact on the nano composite's chemical properties. There exists a lot of space for improvement of cement composites by incorporating nano materials in to the cement matrix.

The requirement of gift work is to check the standard of nano construction materials and to seek out the mechanical properties of nano silicon dioxide concrete i.e. compressive strength, flexural strength and split tensile strength.

II. LITERATURE REVIEW

Yogendran et al, 1987 investigated on silicon dioxide fume on high strength concrete at a relentless water binder quantitative relation (w/b) of zero.34 and that they replaced the silicon dioxide fume by weight of cement with percentages of zero to twenty fifth, with variable dosages of High vary Water Reducer Admixtures (HRWRA). From their results, the most twenty eight day compressive strength was obtained at 15 August 1945 replacement of silicon dioxide fume.

ACI Committee 234 (1995) has according that concrete containing silicon dioxide fume can reduces haemorrhage considerably. This result is caused primarily by the high extent of the silicon dioxide fume to be wetted, there's little free water left within the mixture for haemorrhage. The static modulus of physical property of silicon dioxide fume concrete is seemingly just like that of cement concrete of comparable strength. Committee additionally according that the most contribution of silicon dioxide fume to concrete strength development at traditional solidification temperatures takes place from regarding three to twenty-eight days. At twenty eight days the compressive strength of silicon dioxide fume concrete is often higher.

Shannag (2000) Studied the behaviour of high strength concrete containing natural Pozzolana and silicon dioxide fume. He terminated that sure natural Pozzolana – silicon dioxide fume combination will improve the strength of mortar over natural Pozzolana or silicon dioxide fume alone. additional he instructed that the employment of silicon dioxide fume at 15 August 1945 of the load of cement was ready to turn out comparatively the best strength increase within the presence of regarding 15 August 1945 Pozzolana than while not Pozzolana.

Joshi (2001) ascertained that reduction in cement content at fastened water cement quantitative relation wasn't prejudicial to contemporary and hardened concrete properties and will truly improve performance once silicon dioxide fume was supplementary as 100 percent by weight of cement content. Basu (2001) developed High Performance Concrete (HPC) with SF. He according that by victimization silicon dioxide fume in (HPC) will scale back micro-cracks that tends to develop round the interface between bulk hydrous cement paste and anhydrous cement particles or United Nations reacted pozzolanas. A study has been administrated by Thomas (2001) on dominant alkali-silica reaction (ASR) in concrete with explicit stress on development of a replacement customary practices in North American country. He terminated that use of emulsified cement containing low alkali cement mixed with SF would be a viable suggests that of dominant enlargement in concrete. From the analysis work done by Lewis (2001) it's been ascertained that there's a substantial reduction in rebound from (35-15)% by addition of SF that additionally enlarged the pumpability of high workability combine having slump price on top of 250mm.

Kanstad et al (2001) created a investigation work to assess the crack sensivity of HPC with totally different SF contents and that they found that result of variation of SF content was of minor importance compared to alternative factors viz degree of insulation and condition.

Roncero et al (2002) explicit that incorporation of SF and alternative admixtures may be necessary within the production of HPC so as to get superior mechanical and sturdiness properties. They found that water demand of cement SF system in an exceedingly paste of traditional consistency will increase with temperature and reduces with incorporation of super plasticizers till an explicit indefinite quantity. throughout the intensive analysis work administrated by Vishnoi (2003) and he terminated that SF concrete features a capability to face up to abrasion erosion with higher construction practicability, workability and surface end.

S. Bhanja and B. Sengupta (2004) studied the influence of silicon dioxide fume on the strength of concrete. They found that the optimum strength has obtained within the vary of 5-10% silicon dioxide fume replacement level and for flexural strength is 15 August 1945 to twenty fifth.

K.Perumal (2004) studied the result of partial replacement of cement with silicon dioxide fume on the strength and sturdiness characteristics of high performance concrete. He found that most strength of compressive, split tensile strengths at 100 percent silicon dioxide fume by partial replacement of cement and additionally disclosed that strength and sturdiness connected tests have incontestible superior strength and sturdiness characteristics of HPC mixes containing silicon dioxide fume. This can be thanks to the advance within the small structure thanks to pozzolanic action and filling effects of silicon dioxide fume.

III. METHODOLOGY

3.1 OBJECTIVES AND SCOPE OF PRESENT INVESTIGATION:

Concrete is the most wide used construction material in the world. In recent years, researchers have targeted on the development of concrete quality concerning its mechanical and sturdiness properties.

A reaction between the cement and water turn out metal salt hydrate, which provides strength to the concrete and alternative mechanical properties. The most important disadvantage within the concrete at the recent and hardened state is that the crack formation and its ensuing issues. The cracks in the concrete structures and early degradation are primarily due to the alkali silicon dioxide reaction, that is a chemical reaction that causes cracks in the concrete. Except the higher than, permeableness of gases through pores and micro-cracks within the concrete, that results in corrosion downside within the reinforcement of concrete causes any failure. Moreover, the enlargement and shrinkage within the concrete happen, which cause cracks in concrete at later ages; these are mainly due to the sulphate attack, that are chargeable for the loss of strength in concrete, the chemical leach attributable to the surplus of hydroxide [CH]. The subsequent chemical equation provides the association method in cement

$$2C3S + 6H\ C3S2H3 + 3CH$$

$$2C2S + 4H\ C3S2H3 + CH$$

[Cement chemistry notation: C = CaO; S = SiO2; H = H2O]. With relevance the higher than equations, the C-S-H is that the strength section, whereas the by-product, the CH is not having any building material properties, so it will easily leached out and leads prone to chemical attack. With the addition of appropriate building material materials, mostly siliceous or aluminous, with cement which can react with excess CH and produce additional C-S-H with the replacement of porous CH and refines the pore structure and reduces permeability of gases and water in concrete. The reduction of the CH content throughout cement association related to the chances of sulfate attack and chemical leach will be reduced any, which can tackle to remediate the concrete cracking to some extent. These will be achieved by the application of the supplementary building material materials like silicon dioxide fume, fly ash, Ground Granulated Ballast Slag (G.G.B.S) and etc.

Recently Nano Technology has been introduced in engineering applications. One among the foremost used nano material is Nano Silica (NS). This is often the primary Nano product that has replaced the small silicon dioxide. The advancement created by the study of concrete at nano scale has well-tried that nano silicon dioxide is a lot of higher than silicon dioxide fume used in standard concrete. Nano silicon dioxide possess a lot of pozzolanic nature, it has the capability to react with the free lime during the cement hydration and forms additional C-S-H gel which gives strength, impermeability and sturdiness to concrete.

3.2 OBJECTIVES OF STUDY:

The main objectives of this study is

- To study the mechanical properties of concrete by victimization small silicon dioxide and nano silicon dioxide
- To verify the feasibleness of victimization small silicon dioxide and nano silicon dioxide as a replacement of cement in concrete
- To verify the feasibleness of victimization small silicon dioxide and nano silicon dioxide as a replacement of cement in concrete
- To fulfill safe atmosphere and strength properties by victimization small silicon dioxide and nano silicon dioxide.
- To investigate the various basic properties like compressive strength, split durability and flexural strength of nano silicon dioxide concrete compared with plain concrete.
- In this experimental work, study of strength properties of concrete by victimization nano silicon dioxide and silicon dioxide fume as partial replacement of cement with relevance M40 and M50 grade concretes is created. Strength properties of concrete such as compressive strength, split tensile strength, and flexural strength of concrete are created with completely different replacement levels of normal Portland cement with silicon dioxide fume (5%, 7.5%, 100% and 15%) and nano silicon dioxide (1%, 1.5%, 2% and 2.5%). Strength properties of M40 and M50 grade concretes were additionally studied for a combination of optimum replacement levels of SF (7.5%) and NS (2%).

IV. EXPERIMENTAL INVESTIGATION

4.1 EXPERIMENTAL INVESTIGATION

The experimental programme was administrated to check the mechanical properties like. compressive strength, split durability, and flexural strength of high strength concrete with relevance M40 and M50 grade of concrete, with different replacement levels of ordinary hydraulic cement (ultra tech cement 53 grade) with silica fume (5%, 7.5%, 100 percent and 15%) and nano oxide (1%, 1.5%, 2% and 2.5%). Strength properties of M40 and M50 grade concretes were additionally studied for combination of optimum replacement levels of SF (7.5%) and NS (2%).

4.2 MATERIALS USED AND THEIR PROPERTIES

The materials used in the present investigation are as fallows

1. Cement
2. Aggregates
3. Water
4. Super plasticizer
5. Silica Fume
6. Nano silica

4.2.1 CEMENT

In this gift investigation radical school cement of standard hydraulic cement (OPC) of fifty three Grades was used that satisfies the wants of IS: 12269-1987. The subsequent tests area unit conducted on cement.

4.2.1.1 TESTS ON CEMENT

Following tests area unit conducted to grasp the physical properties of cement

1. Fineness
2. Consistency
3. Initial and Final Setting Time
4. Soundness
5. Specific gravity
6. Compressive strength

TABLE: 1 Physical Properties of Ultra Tech 53 grade (OPC) cement

S.NO	PHYSICAL TESTS	OBTAINED RESULTS	REQUIREMENTS AS PER IS CODES
1	Fineness	4%	Not>10% as per IS 4031 part 1
2	Standard Consistency	31%	IS 4031 part 4
2	Initial Setting time	120 min	Not less than 30 minutes as per IS 4031 part 5
3	Final setting time	250 min	Not more than 600 minutes as per IS 4031 part 5
4	Soundness	3mm	Not>10mm as per IS 4031 part 3
5	Specific gravity	3.11	IS 2720 part 3 (3.15)

4.2.2 AGGREGATE

Aggregates are the important ingredient materials in concrete. They impart bulk volume to the concrete and scale back the shrinkage result. They occupy seventy to eighty % of the overall volume of concrete.

Fine Aggregate: Domestically out there sand collected from watercourse Tungabhadra was used. The subsequent tests area unit conducted on fine mixture per IS: 383-1987

4.2.1.1 Test on fine Aggregate

- Sieve Analysis of Fine Aggregate
- Specific Gravity of Fine Aggregate

Sieve analysis of Fine Aggregate (FA): The sieve analysis of fine mixture is as shown within the Table-2. And from this take a look at the sand utilized in gift study was conformed to zone-II Semi log graph premeditated for sieve analysis of fine mixture is shown in Figure-1

The fineness modulus of fine aggregate is 2.81

Table: 2 Sieve Analysis of Fine Aggregate

S.NO	Sieve size in mm	Weight retained in gm	% weight retained	Cumulative % weight retained (f)	% passing (100-f)
1	4.75	25	2.5	0.25	99.75
2	2.36	20	2	2.25	97.75
3	1.18	130	13	15.25	84.75
4	0.60	570	57	72.25	27.75
5	0.35	225	22.5	94.75	5.25
6	0.15	15	1.5	96.25	3.75

	PAN	15	1.5		100
	Total	1000	100	281	

Fineness modulus = Sum of cumulative percentage retained on standard sieves/100
= 281/100
= 2.81

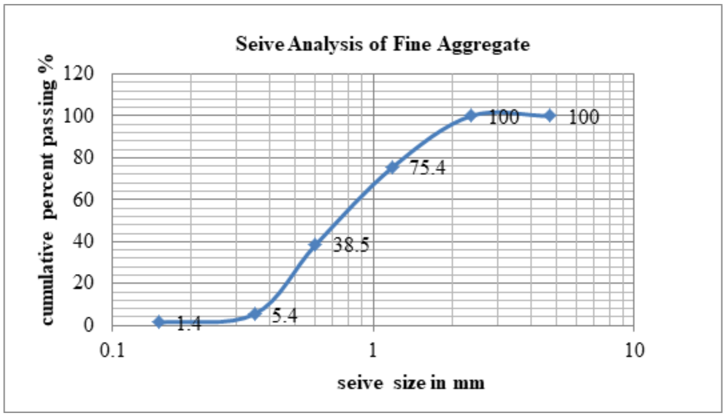

Figure: 1 Sieve Analyses of Fine Aggregate

Specific Gravity of Fine Aggregate:

The specific gravity for fine mixture is set as shown in Table-3

Table: 3 Specific Gravity of Fine Aggregate

SPECIFIC GRAVITY OF FINE AGGREGATE (FA)			
S.No	**Sample Description**		
1	Weight of Dry and Empty pycnometer	W1 = 596	Gm
2	weight of pycnometer + Sand	W2 =1097	Gm
3	weight of pycnometer + Sand + Water	W3 =1800	Gm
4	weight of pycnometer + water	W4 =1485	Gm
5	weight of Oven Dry Aggregate Sample	W5 = 500	Gm

$$\text{Specific Gravity of Fine Aggregate} = \frac{W_5}{((W_2 - W_1)\quad (W_3 - W_4))}$$

$$\text{Specific Gravity of Fine Aggregate} = \frac{500}{((1097 - 596)\quad (1800 - 1485))}$$

The Specific Gravity of Fine Aggregate is 2.68

The physical properties of fine aggregate are shown in Table-4

Table: 4 Physical Properties of Fine Aggregates

S.No	Properties	Results
1	Bulk density, kg/m^3	1650
2	Specific gravity	2.68
3	Fineness modulus	2.81

Coarse Aggregate: The crushed aggregate was used from the local quarry. In this experiment the aggregate was used of 20mm down and tested as per IS: 2386-1963(I, II, III) specification. The subsequent tests area unit conducted on coarse mixture**.**

4.2.1.2 Test on Coarse Aggregate

- Sieve Analysis of Coarse Aggregate
- Specific Gravity of Coarse Aggregate

Sieve analysis of Coarse Aggregate:

The sieve analysis of coarse mixture is shown within the Table-5 and Semi log graph is premeditated for sieve analysis of coarse mixture is shown in Figure-2

Table: 5 Sieve Analysis of Coarse Aggregate

s.no	Sieve size in mm	Weight retained in gm	% weight retained	Cumulative % weight retained (f)	% passing (100-f)
1	80	0	0	0	100
2	63	0	0	0	100
3	50	0	0	0	100
4	40	0	0	0	100
5	31.5	30	0.3	0.2	99.8
6	25	1120	11.2	11.5	88.5
7	20	4170	41.7	53.2	46.8
8	12.5	4360	43.6	96.8	3.2
9	10	220	2.2	99	1
10	6.3	90	0.9	99.9	0.1
11	4.75	10	0.1	100	0
				460.6	

Fineness modulus = Sum of cumulative percentage retained on standard sieves /100

= 460.6/100

The fineness modulus of coarse mixture is 4.60

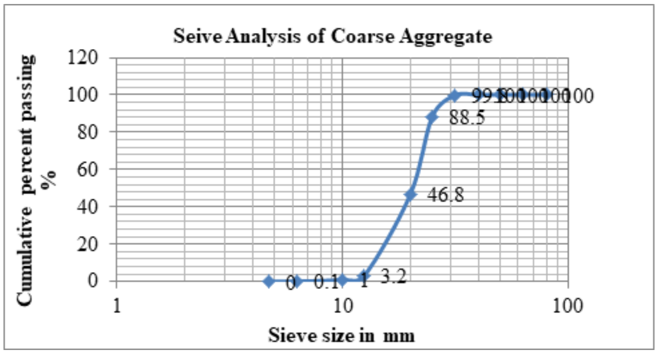

Figure: 2 Sieve Analysis of Coarse Aggregate

Specific gravity of Coarse Aggregate:

The specific gravity for coarse aggregate is determined as shown in Table-6

Table: 6 Specific Gravity of Coarse Aggregate

SPECIFIC GRAVITY OF COARSE AGGREGATE (CA)			
S.No	**Sample Description**		
1	Weight of Dry and Empty pycnometer	$W_1 = 602$	Gm
2	weight of pycnometer + Sand	$W_2 = 1102$	Gm
3	weight of pycnometer + Sand + Water	$W_3 = 1813$	Gm
4	weight of pycnometer + water	$W_4 = 1500$	Gm
5	weight of Oven dry Aggregate Sample	$W_5 = 500$	Gm

$$\text{Specific Gravity of Coarse Aggregate} = \frac{W_5}{((W_2 - W_1) \quad (W_3 - W_4))}$$

$$\text{Specific Gravity of Coarse Aggregate} = \frac{500}{((1102 - 596) \quad (1813 - 1500))}$$

The specific gravity of coarse mixture is a 2.70

The physical properties of coarse mixture area unit shown in Table-7

Table: 7 Physical Properties of Coarse aggregate

S.No	**Property**	**Results**
1	Maximum nominal size	20mm
2	Bulk density (kg/m^3)	1800
3	Specific gravity	2.75

4.2.3 Water

Water used for mix and natural action is pure domestic water, orthodox to IS: 3025 – 1964 half twenty two, half twenty three and IS: 456 – 2000.

4.2.4 Super Plasticizers

Fosroc Aura combine four hundred was used for M40 and M50 Grade of concrete. The properties of super plasticizer is shown in Table- 8

Table: 8 Properties of Fosroc Aura mix 400 Super Plasticizer

Properties	
Appearance	Light yellow coloured liquid
P_H	About 6.0
Volumetric mass @ 20°C	1.09 kg/ litre
Chloride content	Nil
Alkali content	Typically less than 1.5 g Na_2o equivalent liter of admixture

4.2.5 Nano silica

In this experimental study mixture nano oxide of **CemSyn®-XFX** is employed, it's a series of oxide based mostly binders /fillers obtained from Bee-chem.: Chemicals Ltd., Kanpur. The properties of nano silica are shown in Table-10

Table: 9 Properties of Colloidal Nano silica

State	**Dispersed in water**
Active nano particle Content (%w/w)	40.00-41.50
P_H (at 20° C temperature)	9.0-10.0
Specific gravity	1.30-1.32
Particle size	5-40 nm

4.3 MIX DESIGN OF CONCRETE

Mix style may be outlined because the method of choosing appropriate ingredients of concrete like cement, aggregates, water and determinative their relative proportions with the thing of manufacturing concrete of needed minimum strength, workability and sturdiness as economically as attainable. The combine proportions of M40 and M50 grades concrete area unit carried out exploitation IS: 10262-2009. Elaborated combine style for M40 and M50 grade concrete area unit explained in Annexure-A.

4.4 MIXING, CASTING AND CURING

The proportions of designed mixes for M40 (1:1.694:3.107) and M50 (1:1.501:2.827) grades alongside water cement quantitative relation zero.33 and 0.36 was utilized in the current study.

The different share replacement of cement with NS and SF for the each M40 and M50 grades concrete is shown in Table- 12

Table: 12 percentage replacement of cement by using NS & SF

S.NO	Percentage of Nano Silica (N.S)	Percentage of Silica Fume (S.F)
1	1	0
2	1.5	0
3	2	0
4	2.5	0
5	0	5
6	0	7.5
7	0	10
8	0	15

To proceed with the experimental programme, ab initio specimens of ordinary cubes (150mmx150mmx150mm), cylinders (150mm diameters and 300mm length) and beams of (100mmx100mmx500mm), were taken and these specimens were clean while not mud particles and were brushed with oil on all the inner faces to facilitate simple removal of specimens for demoulding.

The mixing of concrete is crucial for the assembly of uniform concrete. The blending ought to be confirm that the concrete becomes consistent, uniform and consistency.

Mixing of concrete is completed in line with IS: 516-1959. For every combine three cubes, three beams and three cylinders were forged. All the specimens were unbroken on the surface and therefore the freshly mixed concrete was poured in to the moulds in 3 layers every layer being compacted completely with a tamping rod to avoid voids. Finally all the specimens were vibrated on the moving table. The specimens are lined with bagging luggage to keep up close wetness content. When twenty four hours the specimens were demoulded and were unbroken immersed in an exceedingly clean cistern for set. When twenty eight days of set the specimens were tested for compressive strength, flexural strength and split durability.

V. RESULTS AND DISCUSSION

5.1 Compressive strength:

The compressive strength of M40 and M50 grade concrete, SF concrete and NS concrete at the age of 28 days is conferred in Table-17.

Supported the experimental results, it absolutely was obtained that there's a significance improvement within the strength of concrete thanks to its high pozzolanic nature of oxide fume and nano oxide and their filling ability.

Compressive strength of 2 mixes M40 and M50 at 28 days age, with replacement of SF was exaggerated bit by bit up to AN optimum replacement level of 7.5% and so remittent. The most twenty eight days cube strength of M40 grade with 7.5% of oxide fume was 61.24 N/mm2 and of M50 grade with 7.5% SF was 69.09 N/mm2.

Compressive strength of M40 and M50 at twenty eight days age with replacement of NS was exaggerated bit by bit up to an optimum replacement level of twenty-two and so remittent. The most twenty eight days cube compressive strength of M40 grade with two NS was 59.61 N/mm2 and of M50 grade with two NS was 69.72 N/mm2.

The compressive strength of M40 grade concrete with partial replacement of cement by 7.5% SF shows 23.56% improvement and of M50 grade with 7.5% replacement shows 22.53% improvement over plain mixes of M40 and M50 grades concrete. The compressive strength of M40 grade concrete with partial replacement of cement by two NS shows twenty.278% improvement and of M50 grade with two replacement shows twenty two.23% improvement compare to plain mixes of M40 and M50 grades concrete. the share variation of compressive strength for M40 and M50 grade concrete area unit shown in Table-17

Compressive strength of M40 & M50 grades were additionally studied with the mix of SF at seven.5% and NS at two which ends in an exceedingly marginal improvement in strengths over individual optimum replacement levels of SF (7.5%) and NS (2%).Figure-7, Figure-8 and Figure-9 shows the variation of compressive strength of M40 & M50 grade with and while not SF and NS replacements.

Table No: 17 Compressive Strength of Concrete at 28 days.

S.No	% Silica Fume	% Nano Silica	Compressive Strength of Concrete in N/mm^2			
			M_{40} Grade	% increase or decreased	M_{50} Grade	% increase or decreased
1	0%	0	49.56	0	57.03	0
2	5%	0	57.18	15.38	61.00	6.94
3	7.5%	0	61.24	23.56	69.89	22.53
4	10%	0	48.74	-1.65	44.58	-21.84
5	15%	0	46.22	-6.73	42.07	-26.23
6	0	1%	54.11	9.18	62.26	9.16
7	0	1.5%	55.25	11.48	65.79	15.34
8	0	2%	59.61	20.27	69.72	22.23
9	0	2.5%	47	-5.16	51.41	-9.85
10	7.5	2%	62.35	25.80	71.5	25.35

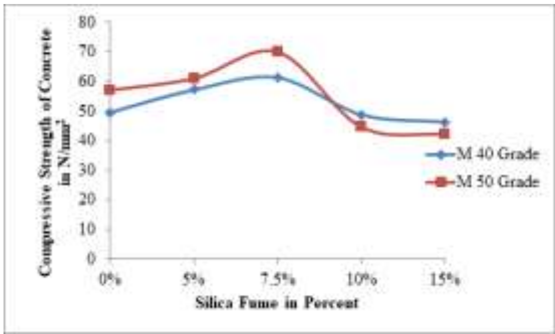

Figure: 7 Variation of compressive strength of Silica Fume concrete at 28 days

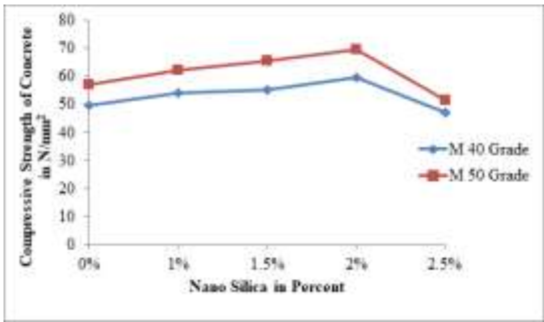

Figure: 8 Variation of compressive strength of Nano Silica concrete at 28 days

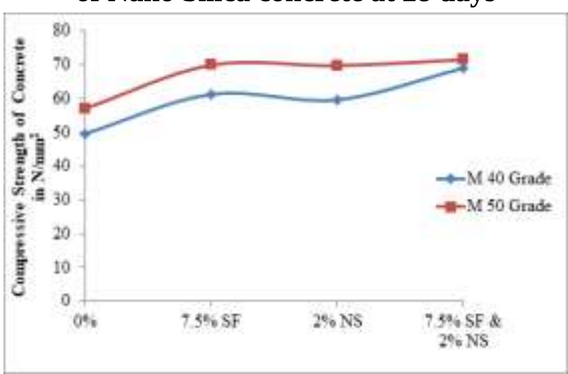

Figure: 9 Variation of compressive strength of both Silica Fume and Nano Silica concrete at 28 days

5.2 Split Tensile Strength:

Split tensile strength of two mixes M40 and M50 at 28 days age, with replacement of SF was increased gradually up to an optimum replacement level of 7.5% and then decreased. The maximum 28 days split tensile strength of M40 grade with 7.5% of silica fume was 3.96 N/mm^2 and of M50 grade with 7.5% SF was 4.12 N/mm^2.

Split tensile strength of M40 and M50 at 28 days age with replacement of NS was increased gradually up to an optimum replacement level of 2% and then decreased. The maximum 28 days Split tensile strength of M40 grade with 2% NS was 4 N/mm^2 and of M50 grade with 2% NS was 4.32 N/mm^2.

The Split tensile strength of M40 grade concrete with partial replacement of cement by 7.5% SF shows 21.47% improvement and of M50 grade with 7.5% replacement shows 17.61% improvement over plain mixes of M40 and M50 grades concrete. The Split tensile strength of M40 grade concrete with partial replacement of cement by 2% NS shows 22.70% improvement and of M50 grade with 2% replacement shows 23.32% improvement compare to plain mixes of M40 and M50 grades concrete. The percentage variation of split tensile strengths for M40 and M50 grade concrete are shown in Table-18

Split tensile strength of M40 & M50 grades were also studied with the combination of SF at 7.5% and NS at 2% which results in a marginal improvement in strengths over respective optimal replacement levels of SF (7.5%) and NS (2%). Figure-10, Figure-11 &Figure- 12 shows the variation of split tensile strength of M40 & M50 grade with SF and NS replacement.

Table No: 18 Split Tensile Strength of Concrete at 28 days

SNO	% Silica Fume	% Nano Silica	Split Tensile Strength of concrete in N/mm^2			
			M_{40} Grade	% increase or decreased	M_{50} Grade	% increase or decreased
1	0%	0	3.26	0	3.50	0

2	5%	0	3.84	17.79	4	14.18
3	7.5%	0	3.96	21.47	4.12	17.61
4	10%	0	3.01	-7.66	3.21	-8.36
5	15%	0	3.27	0.30	3.38	-3.51
6	0	1%	3.74	14.96	3.98	13.64
7	0	1.5%	3.81	17.14	4	14.18
8	0	2%	4	22.70	4.32	23.32
9	0	2.5%	3.25	-0.21	3.68	5.05
10	7.5	2%	4.1	25.76	4.38	25.03

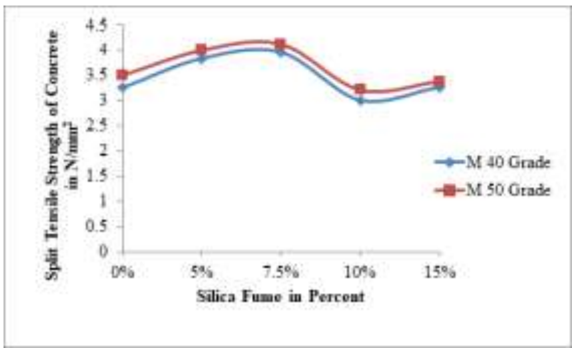

Figure: 10 Variation of Split Tensile Strength of Silica Fume concrete at 28 days

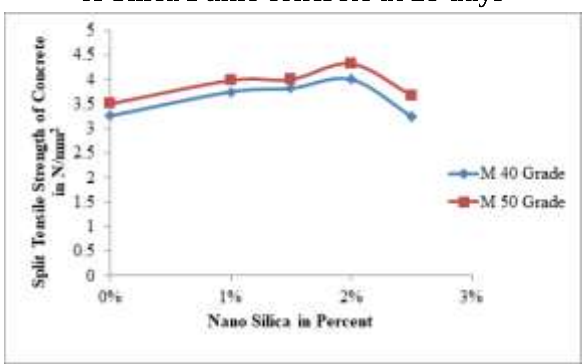

Figure: 11 Variation of Split Tensile strength of Nano Silica concrete at 28 days

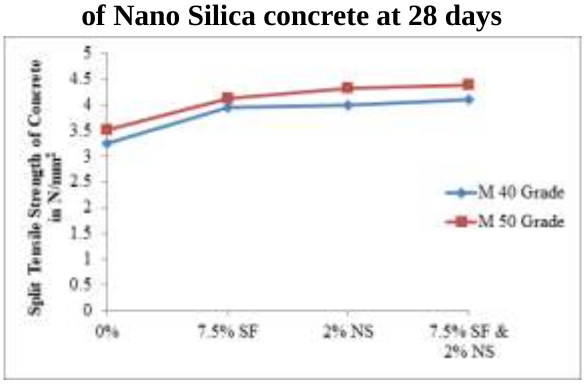

Figure: 12 Variation of Split Tensile Strength of both Silica Fume and Nano Silica concrete at 28 days

5.3 Flexural Strength:

The flexural strength of M40 and M50 grade concrete, SF concrete and NS concrete at the age of 28 days is presented in Table-19

Flexural strength of two mixes M40 and M50 at 28 days age, with replacement of SF was increased gradually up to an optimum replacement level of 7.5% and then decreased. The maximum 28 days flexural strength of M40 grade with 7.5% of silica fume was 4.160 N/mm^2 and of M50 grade with 7.5% SF was 4.560 N/mm^2.

Flexural strength of M40 and M50 at 28 days age with replacement of NS was increased gradually up to an optimum replacement level of 2% and then decreased. The maximum 28 days flexural strength of M40 grade with 2% NS was 4.45 N/mm^2 and of M50 grade with 2% NS was 4.71 N/mm^2.

The Flexural strength of M40 grade concrete with partial replacement of cement by 7.5% SF shows 9.18% improvement and of M50 grade with 7.5% replacement shows 9.35% improvement over plain mixes of M40 and M50 grades concrete. The Flexural strength of M40 grade concrete with partial replacement of cement by 2% NS shows 16.80% improvement and of M50 grade with 2% replacement shows

12.94% improvement compare to plain mixes of M40 and M50 grades concrete. The percentage variation of flexural strengths for M40 and M50 grade concrete results are shown in Table-19

Flexural strength of M40 & M50 grades were also studied with the combination of SF at 7.5% and NS at 2% which results in a marginal improvement in strengths over respective optimal replacement levels of SF (7.5%) and NS (2%). Figure-13, Figure-14 &Figure- 15 shows the variation of Flexural strength of M40 & M50 grade with and without SF and NS replacement.

Table No: 19 Flexural strength of concrete at 28 days

SNO	% Silica Fume	% Nano Silica	Flexural Strength of concrete in N/mm^2			
			M_{40} Grade	% increase or decreased	M_{50} Grade	% increase or decreased
1	0%	0	3.81	0	4.17	0
2	5%	0	4	4.98	4.28	2.63
3	7.5%	0	4.16	9.18	4.56	9.352
4	10%	0	3.76	-1.31	3.98	-4.43
5	15%	0	3.96	3.93	4.05	-2.80
6	0	1%	4	4.98	4.25	1.918
7	0	1.5%	4.2	10.23	4.59	10.07
8	0	2%	4.45	16.80	4.71	12.94
9	0	2.5%	3.8	-0.26	4	-4.07
10	7.5	2%	4.53	18.89	4.84	16.06

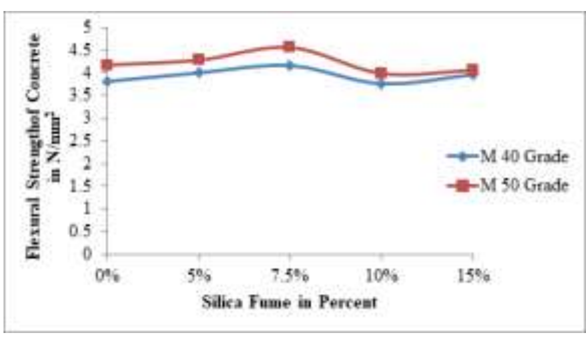

Figure: 13 Variation of Flexural strength of Silica Fume concrete at 28 days

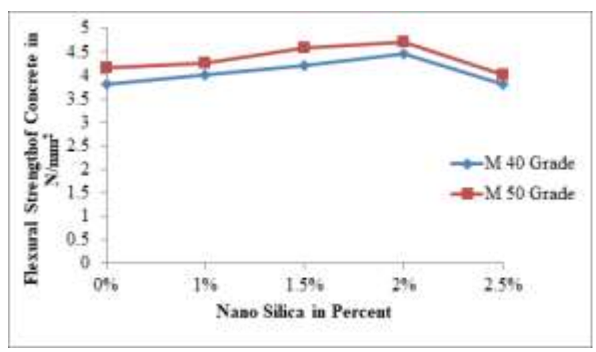

Figure: 14 Variation of Flexural strength of Nano Silica concrete at 28 days

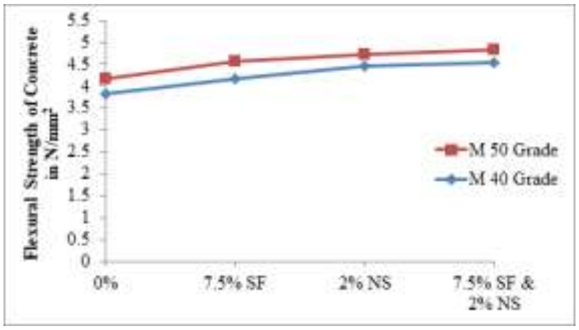

Figure: 15 Variation of Flexural strength of both Silica Fume and Nano Silica concrete at 28 days

VI. CONCLUSION& FUTURE WORK

6.1 CONCLUSIONS

Based on experimental results the following conlusions are drawn

1. Compressive strength, split tensile strength and flexural strength of both mixes M40 and M50 grades were increased gradually up to replacement level 7.5% SF and up to replacement level 2% NS and then decreased.
2. The workability of both M40 and M50 grade concretes were decreased with increase in replacement of SF and NS in concrete.
3. Maximum compressive strength, split tensile strength and flexural strength with replacement of cement by 7.5% SF for M40 grade concrete is 23.56%, 21.47% and 9.18% over conventional mix of M40 grades.
4. Maximum compressive strength, split tensile strength and flexural strength with replacement of cement by 2% NS for M40 grade concrete is 20.27%, 22.70% and 16.80% over conventional mix of M40 grades.
5. Maximum compressive strength, split tensile strength and flexural strength with replacement of cement by 7.5% SF for M50 grade concrete is 22.53%, 17.61% and 9.35% over conventional mix of M50 grades.
6. Maximum compressive strength, split tensile strength and flexural strength with replacement of cement by 2% NS for M50 grade concrete is 22.23%, 22.32% and 12.94% over conventional mix of M50 grades.
7. The percentage increase in compressive strength of concrete with combination of SF at 7.5% and NS at 2% is 25.80% for M40 grade and 25.35% for M50 grade concrete more when compared to normal concrete of M40 and M50 grades respectively.
8. The percentage increase in split tensile strength of concrete with combination of SF at 7.5% and NS at 2% is 25.76% for M40 grade and 25.03% for M50 grade concrete more when compared to normal concrete of M40 and M50 grades respectively.
9. The percentage increase in flexural strength of concrete with combination of SF at 7.5% and NS at 2% is 18.89% for M40 grade 16.06% for M50 grade concrete more when compared to normal concrete of M40 and M50 grades respectively.

6.2 RECOMMENDATIONS FOR FEATURE WORK

1. Further studies can be carried out with the high grade concretes.
2. In this present study colloidal nano silica was used, the further study can be carried out by using nano silica powder.
3. Further studies can be carried out with suitable combinations of different nano materials like nano metakolin, nano iron, and nano titanium and carbon nano tubes.

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