A STUDY ON THE PROPERTIES OF HIGH STRENGTH CONCRETE BY USING THE NANO MATERIALS

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Abstract - *Concrete is the most versatile material. Due to the persistent and continuous demands made on concrete to meet the various difficult requirements, extensive and wide spread research work is being carried out in the area of concrete technology. Engineers are continually pushing the limits to improve its performance with the help of innovative chemical admixtures and supplementary cementations materials like fly ash, silica fume, and granulated blast furnace slag, steel slag etc…*

Researchers have developed variants of concrete composites like Admixture Concrete, Fiber Reinforced Concrete (FRC), Polymer Impregnated Concrete (PIC), High Performance Concrete (HPC), Self Compacting Concrete (SCC), Geopolymer Concrete etc. Presently, Nano Technology being applied to concrete includes the use of nano materials like nano silica, nano fibers etc. By adding the nano materials smart concrete composites with superior properties can be produced.

Nano materials have properties or functions different from similar materials of large size. Nano materials have a larger value of the ratio between surface area and volume than other similar particles in larger size, making the nano materials more reactive. Nano silica will react with C_3S and C_2S in the cement and produce CSH-2 that will form a strong and solid bond of gel.

In the present study strength properties such as Compressive strength, split tensile strength and flexural strength of M_{40} and M_{50} grades of concrete with the use of micro silica (5%, 7.5%, 10%, 15%) and nano silica (1%, 1.5%, 2%, 2.5%) as partial replacement of cement were studied. It was found from the experimental study that concrete composites with superior properties can be produced using micro silica, nano silica and combination of micro silica and nano silica

Key Words: Nano silica, Nano fibers, Nano material concrete

1.0 INTRODUCTION

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 common place concrete could fail to exhibit the desired quality performance or strength. In such cases, pozzolanic or mineral admixtures are accustomed to modify the properties of traditional concrete.

Pozzolanic materials are chemical compound and aluminous material, that in themselves possess very little or no whole price, but will, in finely divided kind and inside the presence of wet, with chemicals react with hydroxide liberated on association, at degree Centigrade, to make compounds, possessing properties. On the association of tri-calcium salt and di-calcium salt, hydroxide is created joined of the merchandise of association. This compound has no whole price and it's soluble in water and will be leached out by the percolating water. The substance or aluminous compound throughout a finely divided kind react with the hydroxide to make terribly stable whole substances of subtle composition involving water, range twenty and compound. Generally amorphous salt reacts much more quickly than the crystalline kind. It's known that hydrated oxide is regenerate in to insoluble material by the reaction of pozzolanic materials.

The reaction unit of measurement typically shown as

Pozzolanic + hydroxide + Water C-S-H (Gel)

This reaction is termed pozzolanic reaction. The reaction involves the consumption of $Ca(OH)_2$ and not production $Ca(OH)_2$. The reduction of $Ca(OH)_2$ improves the sturdiness of cement paste by creating the paste dense and greaseproof.

The use of pozzolanic materials in cement concrete sealed an answer for

- Modifying the properties of the concrete
- Controlling the concrete price
- To overcome the inadequacy of cement
- The economic advantageous disposal of economic wastes

Pozzolanic materials unit of measurement typically divided in to 2 teams

1 **Natural Pozzolans**
- Clay and Shale's
- Opalinc Cherts (A mineral of hydrated silica)
- Diatomaceous Earth

- Volcanic Tuffs and Pumicites.

2 Artificial Pozzolans

- Fly ash
- Blast chamber scum
- Silica fume
- Rice Husk ash
- Metakaolin
- Surkhi.

1.1 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 are altered from that of larger scales. 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. 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.

1.2 NANO TECHNOLOGY IN CONCRETE

One of the foremost and extremely important helpful uses of 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. As water is introduced to cement to make a paste that hardens over time the foremost little structural phases within the hydrous cement paste are

- Calcium salt hydrate gel (C-S-H)
- Calcium hydroxide (C-H)
- Ettringite (a Sulfo matter hydrate)
- Monosulphate
- Unhydrated cement particles and
- Air voids

These tiny structural phases govern the gross properties of materials like strength, durability, physical property and flow ability. Determination of the behavior of megascopic properties provides a radical data of the structure of these phases at the tiniest size level. Among the varied phases, the primary one, C-S-H, is that the most vital product of association and accounts for fifty to seventieth of the full paste volume. This main binding part governs the microscopic properties of the cement paste, however the small and nano scale structure of C-S-H continues to be not well established.

1.3 TYPES OF NANO MATERIALS

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

2. LITERATURE SURVEY

Yogendran etal, 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.

Shannag (2000) Studied the behavior 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

Bjornstrom et al (2004) have investigated the association method of tricalcium salt (C3S) cement and established the fast effects of mixture silicon dioxide and role of water throughout association. They ascertained that CNS accelerate dissolution of C3S section, thereby renders the speedy formation of C-S-H section. If the nano particles are integrated with cement based mostly materials, the new materials may possess some outstanding properties. The pozzolanic activity of NS is a lot of obvious than that of silicon dioxide fume. NS will react with CH crystals that are clad within the surface transition zone (ITZ) between hardened cement paste and aggregates and turn out C-S-H gel. Thus, the dimensions and quantity of CH crystals ar considerably bated and also the early age strength of hardened cement paste in enlarged.

Another study was according by Mastafa Jalal et al (2012) for the natural philosophy, small structure particles, mechanical and sturdiness of high performance self compacting concrete [HPSCC] containing silicon dioxide of small and nano size and with emulsified NS and SF. The addition of NS alone up to twenty weight of cement increased each the compressive and split strengths by regarding sixty two and twenty fifth severally, whereas a pair of NS emulsified with 100 percent SF with management concrete, there was a further strength improvement of Sep 11 and eight severally. They delineated that the improvement of strength wasn't solely due to pour filling result, however additionally by the accelerated cement association thanks to their higher reactivity of NS. Moreover, the water and capillary absorption results disclosed important decrease by the addition of emulsified NS and SF for the binder content. in line with SEM microstructure studies, pure microstructure and smaller pores were achieved by the addition of NS and SF, which may LED to improvement of mechanical, sturdiness and small structural properties of HPSCC.

The result of mixture NS [CNS] on the cement association method compared with SF, similarly as its influence on the gel structure and nano scale mechanical properties of cement paste were studied by Hou et al (2012) and showed that the pozzolanic activity of mixture NS (instead of NS powder) was over that of SF and its association acceleration result was additionally over SF within the early age, however this result was admire that of SF within the later stage

The influence of NS with totally different dosages were studied by Stefanidou, and Papayannis (2012) and according that the addition of NS tends to primarily increase the mechanical response and caused twenty -25% strength improvement. At an equivalent time, with the addition of super plasticizers in a hundred and twenty fifth w/w of cement reduced the water demand and also the strength increase varied from half-hour to thirty fifth. Spectacular changes were additionally recorded within the structure of nano-modified samples because the Ca salt crystal size is larger in samples with high NS content and small structure observation additionally recorded a denser structure in nano-modified samples. in an exceedingly similar line, the result of NS addition with cement pastes on the workability and compressive strength were studied by Lawrence Peter Berra, et al (2012) they found that thanks to the instant interactions between NS and also the liquid section of the building material mixes (mainly dissolved alkalis), the formation of gels characterized by high water retention capacities made a motivating reduction of the combo workability, while not dynamical water / binder quantitative relation and /or addition of super plasticizers.

A.Siva Sai, B.L.P. Swami, B.Sai Kiran (2013) have ascertained the mechanical properties of M60 and M70 grade concrete with small silicon dioxide and together with mixture nano-silica. They found that concrete composites with superior properties will be made with the mixture of micro-silica and nano-silica. prophet Reza Zamani Abyaneh et al (2013) have found that the concrete made with Micro-SiO2 and Nano-SiO2 show higher degrees of quality in their compressive strength than the concrete that solely have Micro-SiO2 in their mixtures. Specimens with a pair of Nano-SiO2 and 100 percent Micro-SiO2 had less water absorption and a lot of resistivity.

3. 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.

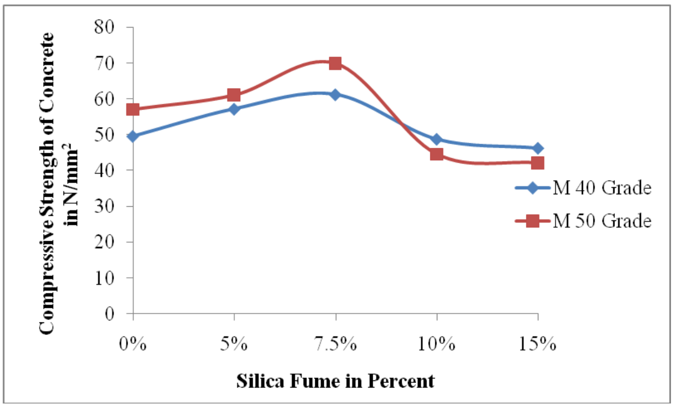
Recently Nano Technology has been introduced in engineering applications. One among the foremost used nano material is Nano Silica (NS). This is often the primary Nano product that has replaced the small silicon dioxide. The advancement created by the study of concrete at nano scale has well-tried that 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.

4. RESULTS AND DISCUSSION

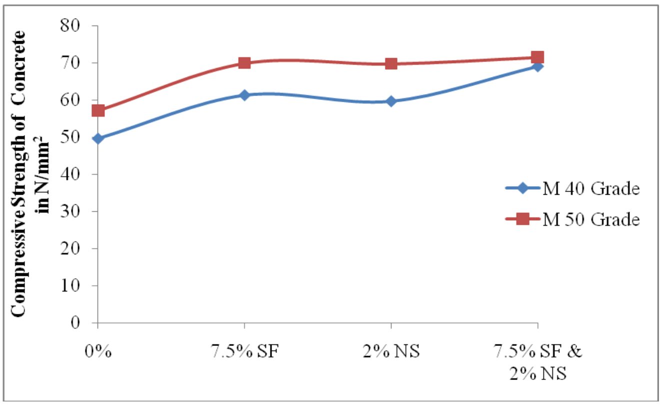
Table 1 Compressive Strength of Concrete at 28 days

S.No	% Silica Fume	% Nano Silica	Compressive Strength of Concrete in N/mm²			
			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

Graph 1 Variation of compressive strength of Silica Fume concrete at 28 days



Graph 2 Variation of compressive strength of Nano Silica concrete at 28 days



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

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%. 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 22. The twenty eight days cube compressive strength of M40 grade is 59.61 N/mm2 and of M50 grade is 69.72 N/mm2.

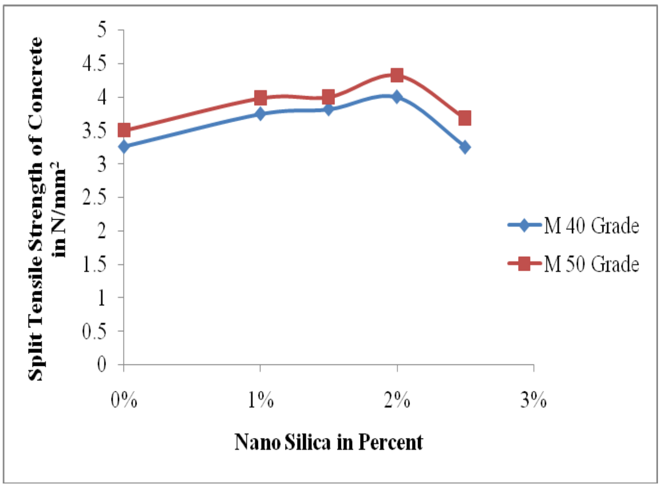
The compressive strength of M40 grade concrete with partial replacement of cement by 7.5% SF shows 23.56% improvement and of M50 grade with 7.5% replacement shows 22.53% improvement over plain mixes of M40 and M50 grades concrete. The compressive strength of M40 grade concrete with partial replacement of cement 20.278%

improvement and of M50 grade with two replacement show 22.23% improvement compare to plain mixes of M40 and M50 grades concrete

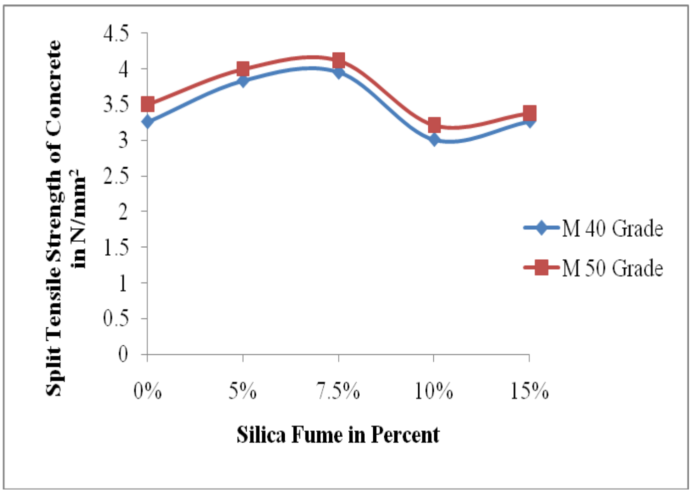
Table 2 Split Tensile Strength of Concrete at 28 days

SNO	% Silica Fume	% Nano Silica	Split Tensile Strength of concrete in N/mm²			
			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

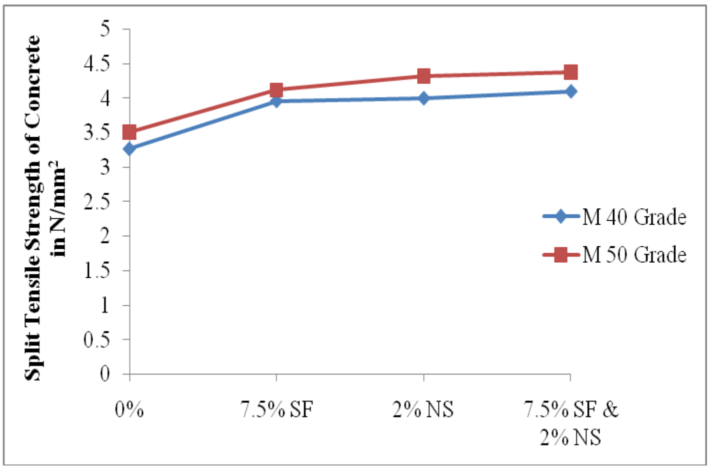
Graph 3 Variation of Split Tensile Strength of Silica Fume concrete at 28 days



Graph 4 Variation of Split Tensile strength of Nano Silica concrete at 28 days



Graph 5 Variation of Split Tensile Strength of both Silica Fume and Nano Silica concrete at 28 days



5. 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/mm² and of M50 grade with 7.5% SF was 4.12 N/mm².

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/mm² and of M50 grade with 2% NS was 4.32 N/mm².

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.
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%).

6. CONCLUSION

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.

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