Impact of Nano Material (Nano-Silica & Nano-Titanium dioxide) on the Fresh and Mechanical Properties of Concrete.

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***Abstract** - The use of nanotechnology has resulted in substantial advances in the concrete industry, ushering in novel construction methods. Concrete's application in buildings is due to its low cost, strength, and moldability. However, environmental concerns drive research into alternatives. Adding ultra-fine additives, such as nano-silica, can improve cementitious system performance, reduce maintenance and life cycle costs, and enhance the properties of plastic and hardened materials, resulting in a more sustainable construction process. The most recent breakthroughs in nanotechnology provide hopeful solutions to these difficulties. This study investigates the simultaneous use of nano silica (NS) and nano-titanium dioxide ($NTiO_2$) to improve the mechanical qualities and sustainability of concrete. This study investigates the influence of nano-silica and nano-titanium dioxide (nano-TiO_2) on the mechanical characteristics of concrete. As a result, combining nanoparticles is more helpful than using them alone. Many studies support the inclusion of nanoparticles to optimize the use of concrete in building structures, both alone and in combination to study the fresh and harden properties of nano silica and nano titanium dioxide with partial replacement of cement in different percentage such as 0%, 1% 1.5%, 3%, and 3% 2.5%, 1% are evaluated.*

Key Words: conventional concrete, Concrete mix with nano material (Nano-silica and Nano-titanium dioxide, Workability, Compressive-strength, Tensile-strength, and Flexural-strength.

1.INTRODUCTION:

Concrete is the most-common building-material because of its strength, durability, and low cost. Civil engineering constructions frequently employ it, and its versatility makes it ideal for a wide range of construction projects. However, worries about the an environmental-impact of cement manufacturing have prompted continued research into alternatives. The goal is to create more durable and ecologically friendly concrete while lowering maintenance and life-cycle expenses. The use of ultra-fine additives such as nano-silica and nano titanium di oxide can increase the properties of plastic and hardened materials, making concrete a preferred alternative for construction projects.

1.1 Nanotechnologies in concrete:

Since its first examination in the late 1980s, the use of nanoparticles to improve the mechanical behavior of cementitious composites has been the topic of ongoing research for nearly two decades. Nanomaterials offer incredible features and capacities that can improve concrete behavior. Nano-SiO2, made up of pozzolanic components that react with cement hydration products, is one of the most widely used nanomaterials. The inclusion of nano-SiO2 improved cement qualities such as compressive and flexural strength, resistance to water penetration, sulfate defense, and reduced calcium leaching. Nanotechnology remains a rapidly growing sector in which researchers from a variety of industries, including construction, continue to seek breakthroughs. Nonetheless, the -concrete is the world's most used building material due to its low cost and strength. With rising demand each year, over 4.2 billion tons of cement were manufactured in 2019. It is vital to note that the identical materials at the nanoscale have different properties than those at the microscale. This study investigates of-the simultaneous use of-nano silica (NS) and nano titanium oxide (NTO) to improve the mechanical qualities and sustainability of concrete. The percentages of nano silica are 1%, 1.5%, and 3%, respectively, whereas nano titanium dioxide is 3%, 2.5%, and 1%. Following the experimental investigation, the strengths of the mechanical properties grew as the amount of nano-silica in the concrete-increased, while the concrete's workability decreased.

2. AIM AND OBJECTIVE:

- This research aims to investigate how nanoparticles affect the mechanical-properties of concrete material.
- The study aims to test the fresh and hardening qualities of nano silica and nano titanium dioxide with varying percentages of cement substitution, including 0%, 1%, 1.5%, 3%, 2.5%, and 1%.
- Nano-TiO_2 hardness increases proportionally with nanofiller concentration.

3. LITRATURE REVIEW:

- **Praveen Kumar et al. (2019)** sought to assess the performance features of rice husk ash (RHA) based self-compacting concretes including micro TiO2. The concretes had a water-to-binder ratio of 0.41, with 10% RHA replacing cement. The nanoparticle additions ranged from 1% to 5%, respectively. The results showed that adding 3% nano-TiO2 increased compressive strength by 8.5% when compared to control concrete, split tensile strength by 18%, and flexure strength by 13%. The durability characteristics state that at 3% of nano-TiO2, the chloride penetration is less, as evaluated using RCPT test, and the percentage of weight loss is reduced following the hydrochloric acid assault.

- **Mukherjee and Barai (2014)** the compressive strength and properties of the Interfacial Transition Zone (ITZ) of concrete using recycled aggregates and nano-silica. The addition of nano-silica improved concrete's compressive strength and microstructure.
- **Mostafa Jalal et al. (2013)** Using fly ash and nano titanium oxide, we sought to examine the performance characteristics in both fresh and hardened conditions. The cement was substituted with 15% fly ash, and nano TiO2 levels ranged from 1% to 5%. The decline in fresh state properties was offset by the incorporation of fly ash into the composite. However, the permeability properties drastically reduced with the addition of nano-TiO2. The results showed that at 4% nano-TiO2, the compressive strength, split tensile strength, and flexure strength rose to their maximum when compared to control concrete. The durability characteristics show that at 4% nano-TiO2, the percentage of water absorption is lower, and the chloride penetration depth is reduced due to the densified microstructure. In an attempt to assess durability attributes of SCC containing four different types of nano particles (Nano Tio2, Nano Zro2, Nano Al2o3 and Nano Fe2o3) A. H. Shekari et al. (2011) reported that the chloride penetrability in concrete can be reduced up to 80% in comparison to conventional concrete with a 1.5% addition of nano particles.

4. MATERIAL REQUIRED FOR WORK:

4.1 Nano silica and nano titanium dioxide: We bought powdered nano-silica from various manufacturers and investigate the effects of nano-silica penetration on to the fresh characteristics of concrete after lab testing-we discovered 95% of nano-silica particles are 12 nm in size and have a specific gravity of 2.4. $NTiO_2$ is available for purchase, with particle sizes-ranging from 15-30nm. The photocatalytic properties of nano-titanium oxide are highly valued, as is its ability to improves the compressive strength and lifespan-of-concrete, especially under hard environmental conditions. The combined impact of nano-titanium dioxide and nano-silica. Although there hasn't been much research on them together, early studies show that the fresh and hardened characteristics of concrete have greatly enhanced.

4.2 Cement: The main component/or leading material in cement composition is lime, is binding medium 60-65% of the composition, and the remaining components are combined in the right ratio to form cement; cement is the properties for cohesion which accounts the materials other than lime are silica, alumina, magnesia, iron oxide, sulphur trioxide, and alkali. The specific-gravity and a fineness of-cement are 3.070 and 8%, respectively.

4.3 Fine Aggregate: The aggregate, for the most part, passes through the 4.75 mm IS filter and contains no coarser particles than the standard allows. According to the source, fine aggregate can be defined as: The current study's fine aggregate was river sand, which was easily available locally and met IS 383:1970's Grading Zone II. Several tests were done on the raw sample to determine the quality of the fine aggregates; all testing was carried out in a laboratory setting in accordance with Indian laws. It should be absolutely inactive. The grain should be crisp, powerful, and angular. It should be well-graded. Its specific-gravity, water-absorption, and fineness-modulus are, respectively, 2.461, 1.121, and 2.571%.

4.4 Coarse aggregate: Coarse particles are the principal component of the concrete mix. Aggregates classed as coarse range in particle size from 4.75 mm to 20 mm. Several tests were performed on the raw material to establish the quality of the coarse aggregates, and all of the results were discovered after the test was completed in the lab. All tests were completed in a laboratory in accordance with Indian standards. The coarse aggregate specific-gravity, fineness-modulus, and water-absorption values are 2.570, 7.29, and 0.79%, respectively.

4.5 Water: Clean, fresh water devoid of organic components, silt, oil, sugar, chloride, and acidic chemicals is used to cast and cure the specimens. Cement paste, produced by hydration, binds aggregate particles to form a flexible concrete mixture. While it is used, ordinary tap water might lead to segregation in excess. Water is essential to the creation of cement gel, and both its quantity and quality need to be carefully considered. Water meeting IS 456-2000 requirements was utilized for mixing and curing.

5. MIX DESIGN STEPS FOR M-35 GRADE CONCRETE MIX:

(A) Design Required:

1. Grade of concrete mix = M-35
2. Type of cement material = OPC53 grade
3. Size of aggregate = 20 mm

3. Degree of site control = Good condition
4. Exposure condition = Very-severe
5. Workability of concrete = 75 mm(assumed)
6. Method of concrete-place = manually
7. Minimum cement-content = 340.00Kg/m^3

(B) Test result for material:

I. Sp. gravity of cement = 3.071
II. Sp. gravity of coarse-aggregate = 2.571
III. Sp. gravity of fine-aggregate = 2.461
IV. Water-absorption of (coarse-aggregate) = 0.791
V. Water absorption for sand(fine-aggregate) = 1.121
VI. Conforming of sand = zone-II

(C) Target mean strength = 43.250N/mm^2

(D) Selection of w/c(water-cement) ratio= 0.51

(E) Selection of water-content = 169.904 kg/m^3

(F) Selection of Cement content = 375.490 kg/m^3

(G) Selection of coarse aggregate = 991.094 kg/ m^3

(H) Selection of fine aggregate = 555.310 kg/m^3

5.1 Tests on concrete mixture: Slump Cone test for workability of concrete: Constructing a concrete workability test is required since concrete can be mixed, transported, and used in certain applications. The slump test is the common way to determine workability-of-concrete. This test is the most often used procedure for assessing concrete consistency, whether on-site or in a laboratory. The slump-cone is filled with three layers of newly mixed concrete, each stamped 25 times with a standard rod. The C:S: A ratio for normal concrete is 1:1.90:3.41, but the ratio for nano-silica concrete is 1.1.99:3.55.

Fig 1 Slump cone test of concrete

Table-1 Slump Values of Conventional Concrete

Addition of nano silica and nano titanium dioxide is Inclusion decreases workability.

Mix proportion	Nano Silica %	TIO_2 %	W/C Ratio	Slump Value	Average Value
Conventional	0.00	0.00	0.49	81	83
				85	
				83	
Mix-01	1.00	3.00	0.51	79	78.66
				80	
				77	
Mix-02	1.50	2.50	0.51	86	81
				79	
				78	
Mix-03	3.00	1.00	0.51	75	78.33
				81	
				79	

6. RESULT AND DISCUSSION OF THE SAMPLE:

6.1 CASTING OF SPECIMEN: The specimens were casted in the-cube, cylinder, and beam moulds samples were cured in a water pond for a period of seven and twenty-eight days. At seven and twenty-eight days of age, the nanomaterial concrete was compared to normal concrete samples.

Fig-2: - Casting of Cubes, Cylinders & Beams.

6.2 Compressive Strength test: The size of the concrete cube specimen was 150×150×150mm, and it tested in 7 days and 28 days after curing. P is the load, and A is the cross-sectional area, the formula for compressive strength= P/A.

Fig-3: Compressive strength-test of concrete cube in U.T.M.

Table-02 Compressive Strength results for Concrete.

S. No.	Mix proportion	Nano silica %	N-TIO_2 %	Age (Days)	stress (N/mm^2)
01	Conventional	0.00	0.00	07	24.86
	Mix-01	1.00	3.00		26.57
	Mix-02	1.50	2.50		26.84
	Mix-03	3.00	1.00		28.21
02	Conventional	0.00	0.00	28	36.89
	Mix-01	1.00	3.00		42.91
	Mix-02	1.50	2.50		39.56
	Mix-03	3.00	1.00		44.27

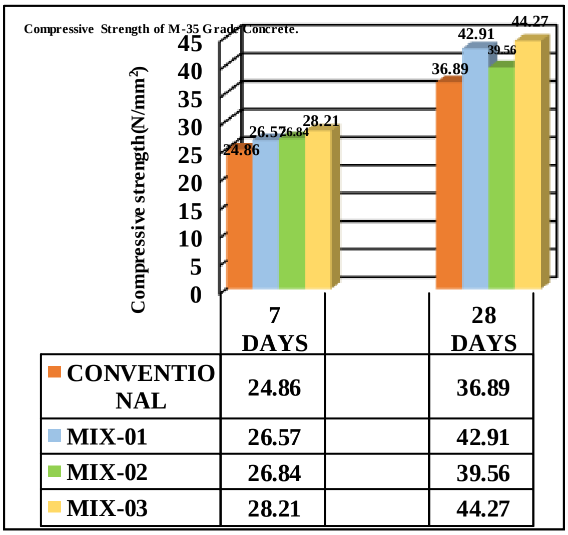

chart-1: Compressive strength behaviour for conventional-concrete after 07-&-28-days vs nano silicate concrete.

6.3 Split tensile strength: Using cylinders for split tensile strength its diameter of 150mm and a height of 300mm. It took seven and 28days to pour and test the cylinder. P is the load, D is the cylinder's diameter, and L is the cylinder's length. The tensile strength is equal to $2P/\pi DL$.

Fig- 4: Split tensile strength-test of cylinder in U.T.M.

Table-03 Tensile-Strength results for concrete specimens:

S. No.	Mix proportion	Nano silica %	% TIO_2	Age (Days)	stress (N/mm^2)
01	Conventional	0.00	0.00	07	3.79
	Mix-01	1.00	3.00		4.78
	Mix-02	1.50	2.50		4.89
	Mix-03	3.00	1.00		6.87
02	Conventional	0.00	0.00	28	6.74
	Mix-01	1.00	3.00		5.58
	Mix-02	1.50	2.50		5.18
	Mix-03	3.00	1.00		7.74

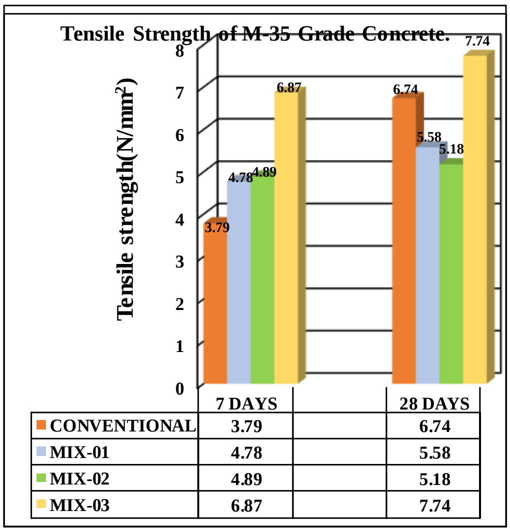

Chart-2: Tensile strength behaviour of concrete after 7 and 28-days vs nano silicate concrete mix.

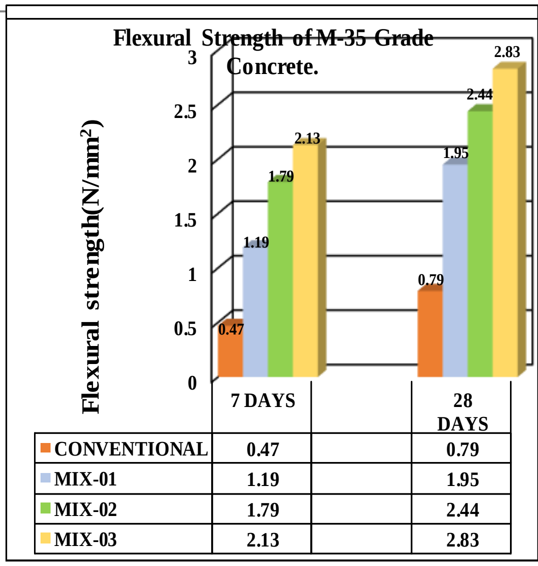

Chart-3: Flexural strength behaviour of conventional concrete after 7 and 28-days vs nano silicate concrete mix.

6.4 Flexural Strength test: the bending is produced a universal testing apparatus applied a force of 2000 KN to a specimen of a beam of 150x150x700mm size observed that the strength of the concrete mix had grown between 7 and 28 days. WL/bd2 = f strength.

Fig-: flexural strength test in U.T.M.

Table-4 Flexural-Strength results for concrete specimen:

S. No.	Mix proportion	Nano silica %	TIO2 %	Age (Days)	stress (N/mm²)
01	Conventional	0.00	0.00	07	0.47
	Mix-01	1.00	3.00		1.19
	Mix-02	1.50	2.50		1.79
	Mix-03	3.00	1.00		2.13
02	Conventional	0.00	0.00	28	0.79
	Mix-01	1.00	3.00		1.95
	Mix-02	1.50	2.50		2.44
	Mix-03	3.00	1.00		2.83

8. CONCLUSION:

- Present study, it was concluded that the addition of different concentrations of nano silica and nano titanium silicate nano particles enhanced some of the material properties.
- Increased hardness of the concrete specimen.
- The most optimum enhancement is 1% for this work.
- The aforementioned result indicates that achieves 1% of the mix-35's compressive, and tensile strengths as compare to conventional concrete have same grade.

9. SCOPE OF RESEARCH:

- Evaluation of the bond, creep, shrinkage, and other engineering parameters of concrete treated with nano-silica is necessary.
- The creation of concrete with nano-silica injection that is lightweight and incredibly durable. Need should be the primary subject of study.

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