Effect of Nano-Silica and Nano-Titanium dioxide on the Fresh and Mechanical Properties of Concrete.

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Abstract - *The outstanding properties of concrete, such as its cost-effectiveness, strength, and moldability, account for its widespread use in construction. Concerns over the environmental impact of cement manufacturing, however, drive ongoing research into alternatives. The production of more durable and environmentally friendly concrete, the wise use of resources, and the ensuing decrease in maintenance and life cycle costs can all lead to improved cementitious system performance. The goal of adding ultra-fine additives such as nano-silica to cementitious systems is to improve the characteristics of plastic and hardened materials. The latest advancements in nanotechnology offer promising solutions to these issues. This work explores the simultaneous application of nano-silica (NS) and nano-titanium oxide (NTO) to enhance the mechanical properties and sustainability of concrete.*

Key Words: traditional concrete, Concrete with Nano-silica and Nano-titanium oxide, Workability, Compressive, Tensile, and flexural strength.

1.INTRODUCTION:

The outstanding properties of concrete, such as its cost-effectiveness, strength, and moldability, account for its widespread use in construction. Concerns over the environmental impact of cement manufacturing, however, drive ongoing research into alternatives. The production of more durable and environmentally friendly concrete, the wise use of resources, and the ensuing decrease in maintenance and life cycle costs can all lead to improved cementitious system performance. The goal of adding ultra-fine additives such as nano-silica to cementitious systems is to improve the characteristics of plastic and hardened materials.

1.1 Nanotechnology in concrete:

The latest advancements in nanotechnology offer promising solutions to these issues. This work explores the simultaneous application of nano-silica (NS) and nano-titanium oxide (NTO) to enhance the mechanical properties and sustainability of concrete. The percentage of nano-silica is 1%, 1.5%, 3% and nano titanium dioxide is 3% 2.5% and 1.0%. Following the experimental examination, the strength of the mechanical qualities increased as the amount of nano-silica in the concrete increased, but the concrete's workability also dropped.

2. AIM:

An experimental study examining how nano-silica and nano titanium oxide affect the mechanical and fresh properties of M-35 grade concrete.

2.1 OBJECTIVE:

- To ascertain the impact of concrete's workability.
- to investigate how nano silica affects concrete's compressive and tensile strength.
- Research should primarily concentrate on creating lightweight, extremely durable concrete that contains nano silica.

3. LITRATURE REVIEW:

G. Dhinakaran et. al. (2014) analysed the microstructure and strength properties of concrete with Nano SiO2. The silica was ground in the planetary ball mill till nano size reached and it was blended in concrete with 5%, 10% and 15% b.w.c. The experimental results showed gain in compressive strength with maximum strength for 10% replacement.

Heidari and Tavakoli (2012) investigated the combined effect of replacement of cement by ground ceramic powder from 10% to 40% b.w.c. and nano SiO2 from 0.5 to 1%. A substantial decrease in water absorption capacity and increase in compressive strength was observed when 20% replacement is done with ground ceramic powder with 0.5 to 1% as the optimum dose of Nano SiO2 particles

Alireza Naji Givi et.al. (2012) studied the effect of Nano SiO2 particles on water absorption of RHA blended concrete. It is concluded that cement could be replaced up to 20% by RHA in presence of Nano SiO2 particle up to 2% which improves physical and mechanical properties of concrete.

4. MATERIAL REQUIRED:

4.1 Nano silica and nano titanium dioxide: We purchased powdered nano-silica from a variety of industries. Here, we study the effects of nano-silica penetration on the fresh properties of concrete. After testing in the lab, we found that 95% of the particles in nano-silica are 12 nm in size and have a specific gravity of 2.4. NTO is available for purchase and has a particle size range of 15–30 nm. The photocatalytic qualities of nano-titanium oxide are highly prized, as is its capacity to improve the compressive strength and longevity of concrete, particularly under harsh environmental circumstances. The Combined Impact of Nano-Titanium dioxide and Nano-Silica Even though there isn't much research on them together, early tests indicate that concrete's fresh and hardened qualities have significantly improved. This study attempts to close this gap by methodically examining their cumulative influence.

4.2 Cement: The concrete mix design utilizes regular, common portland cement. Following the purchase of a cement bag, a number of tests were performed on cement samples to determine their quality. The laboratory testing yielded all of the cement sample results according to Indian guidelines; cement samples were used for all of the tests. 3.07 and 8% are the specific gravity and fineness of cement, respectively.

4.3 Fine Aggregate: The raw components for the concrete mix design are fine aggregates, defined as aggregates with a particle size of less than 4.75 mm. To determine the fine aggregates' quality, a number of tests were run on the raw sample, and every test was carried out in a lab setting in accordance with Indian regulations. This research effort uses zone II sand as fine aggregate. Its specific gravity, water absorption, and fineness modulus are, in that order, 2.46, 1.12, and 2.587%.

4.4 Coarse aggregate: The primary component of the concrete mix is coarse particles. The 4.75 mm to 40 mm particle size range includes coarse-classified aggregates. Several tests were conducted on the raw material to determine the quality of the coarse aggregates, and all the results were discovered after the test was carried out in the laboratory. All the tests were conducted in a laboratory as per Indian standards. The coarse aggregate's specific gravity, fineness modulus, and water absorption are 2.57, 7.29 and 0.79% respectively.

4.5 Water: The concrete mix is mixed using standard tap water. The water samples underwent a pH test, and the results showed that the water's pH was 7.2.

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

(A) Design Required:

1. Grade Of concrete = M35
2. Type of cement used = OPC-53
3. Nominal Size of aggregate used = 20 mm
3. Degree of site control = Good
4. Exposure condition = Very Severe
5. Workability of concrete assumed = 75 mm
6. Method of concrete placing = manual
7. Minimum cement content = 340 kg/m^3

(B) Test result for material:

1. Specific gravity of cement = 3.07
2. Specific gravity of coarse aggregate = 2.57
3. Specific gravity of fine aggregate = 2.46
4. Water absorption of coarse aggregate = 0.79
5. Water absorption for fine aggregate = 1.12
6. Conforming zone of sand = zone II

(C) Target mean strength = 43.25 N/mm^2

(D) Selection of water cement ratio = 0.45

(E) Selection of water content = 165.579 kg/m^3

(F) Cement content = 375.496 kg/m^3

(G) Coarse aggregate (per m^3) = 991.094 kg

(H) Fine aggregate (per m^3) = 555.31 kg

5.1 Tests on concrete mixture:

Workability test:

It is possible to mix, transport, and use concrete for certain purposes. The slump test serves as the methodology for evaluating workability. The slump cone is filled with three layers of newly mixed concrete, each of which is tamped 25 times with a regular rod. The C:S:A ratio for conventional concrete is 1:1.67:3.03, while the C:S:A ratio for nano-silica concrete is 1.1.47:2.63.

Table-1 Slump Values of Conventional Concrete.

S. No.	W/C Ratio	Slump Value(mm)	Average Value
01	0.43	81	83.00
02	0.43	85	
03	0.43	83	

Table-2 Slump Values of Nano-silicate concrete.

S. No.	W/C Ratio	Slump Value(mm)	Average Value
01	0.44	79	78.66
02	0.44	77	
03	0.44	80	

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

6. RESULT AND DISCUSSION OF THE SAMPLE:

6.1 CASTING OF SPECIMEN: The specimens were cast in accordance with IS 10086-1982. The unfinished cube, cylinder, and beam samples were cured in a water pond for a period of 28 days. At seven and twenty-eight days of age, the nanomaterial concrete was compared to normal concrete.

Fig-1: - Casting of Cubes, Beam & Cylinders.

Compressive Strength test: The size of the cast concrete cube was 150 × 150 × 150 × 150 mm, and it underwent testing for one week and four weeks. P is the applied load, and A is the cross-sectional area (150 × 150 × 1500 mm); hence, the formula for compressive strength is P/A.

Fig-2: Compressive strength test in Universal testing machine.

Table-3 Compressive Strength results for Concrete.

S. No.	Mix proportion	Nano silica	TIO_2	Age (Days)	stress (N/mm^2)
01	Conventional	0.00	0.00	07	23.85
	Mix-01	1.00	3.00		25.87
	Mix-02	1.50	2.50		24.93
	Mix-03	3.00	1.00		26.05
02	Conventional	0.00	0.00	28	37.42
	Mix-01	1.00	3.00		43.69
	Mix-02	1.50	2.50		39.85
	Mix-03	3.00	1.00		46.25

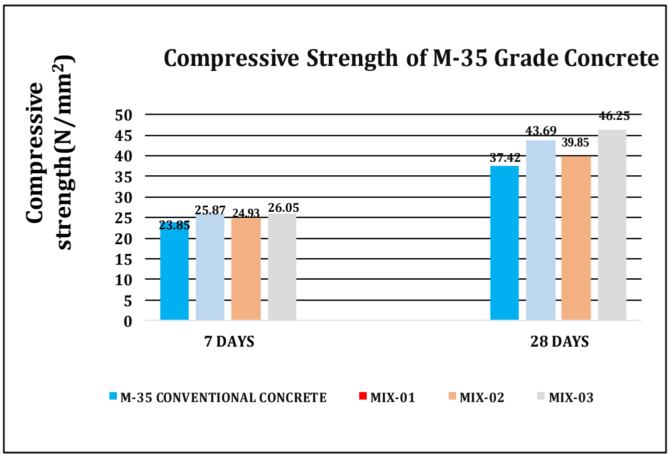

chart-1: Compressive strength behaviour for conventional concrete after 7 and 28-days vs nano silicate concrete.

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

Fig- 3: Split tensile strength test in Universal testing machine.

Table-4 Tensile Strength results for concrete specimen:

S. No.	Mix proportion	Nano silica	TIO_2	Age (Days)	stress (N/mm^2)
01	Conventional	0.00	0.00	07	3.85
	Mix-01	1.00	3.00		4.87
	Mix-02	1.50	2.50		4.93
	Mix-03	3.00	1.00		6.05
02	Conventional	0.00	0.00	28	6.42
	Mix-01	1.00	3.00		5.69
	Mix-02	1.50	2.50		5.12
	Mix-03	3.00	1.00		7.85

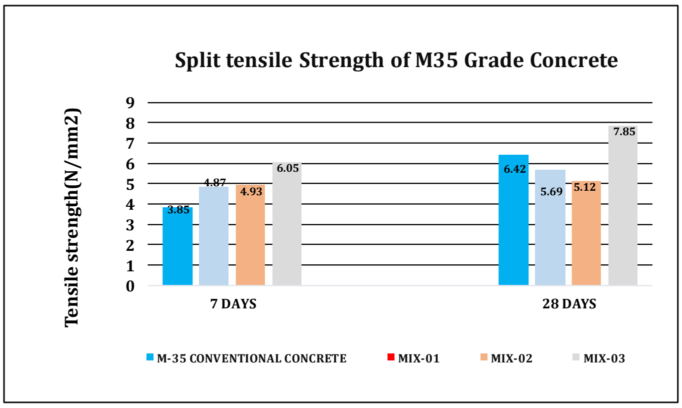

Chart-2: Tensile strength behaviour of concrete after 7 and 28-days vs nano silica concrete.

Flexural Strength test: To produce bending, a universal testing apparatus delivers a force of 2000 KN to a specimen of a beam of 150 x 150 x 700 mm. The maximum applied load on the specimen is recorded. We observed that the strength of the concrete mix had grown between 7 and 28 days. WL/bd2 is equivalent to f strength.

Fig-4: flexural strength test in universal testing machine.

Table-7 Flexural Strength results for conventional concrete:

S. No.	Mix proportion	Nano silica	TIO_2	Age (Days)	stress (N/mm^2)
01	Conventional	0.00	0.00	07	0.45
	Mix-01	1.00	3.00		1.17
	Mix-02	1.50	2.50		1.80
	Mix-03	3.00	1.00		2.17
02	Conventional	0.00	0.00	28	0.77
	Mix-01	1.00	3.00		1.91
	Mix-02	1.50	2.50		2.47
	Mix-03	3.00	1.00		2.89

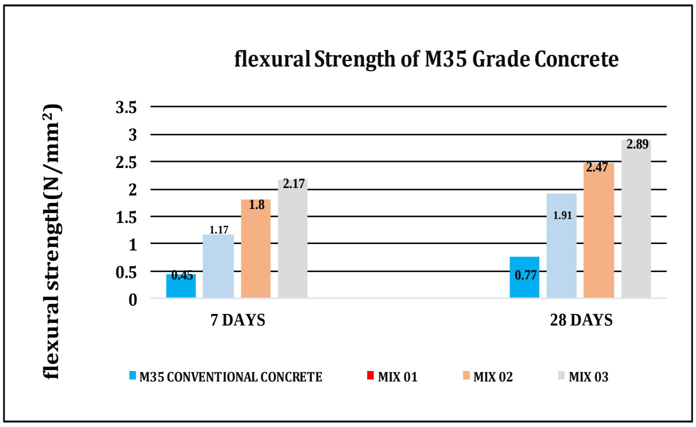

Chart-3: Flexural strength behaviour of conventional concrete after 7 and 28-days vs nano silicate concrete.

8. CONCLUSION:

- the present study, it was concluded that the addition of different concentrations of titanium silicate nano particles enhanced some of the material properties.
- Increased hardness of the concrete.
- The most optimum enhancement is 1%.
- The aforementioned result indicates that achieves 1% of the mix-35's compressive, and tensile strengths.

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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