Experimental Study on use of Nano Titanium Dioxide in concrete

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ABTRACT

This study aimed to investigate the properties of concrete containing various percentages of NT, such as the fresh properties, mechanical properties (compressive strength, split tensile strength, and flexural strength), durability, and microstructural properties. In addition, we investigated the ability of cement incorporated with NT to resist the ingress of chloride ions in marine environments by measuring the diffusion coefficients, ion flux, current density, and conductivity. We can conclude that there is a need for the incorporation of novel materials such as NT into cement-based materials as they can improve the strength and durability of structures, thus reducing their maintenance and repair costs by improving the overall performance of cementitious composites.

Keywords: Compressive Strength, Flexural Strength, Nano Titanium Dioxide, Nano Concrete. Nano titanium dioxide (TIO2)

I. INTRODUCTION

Recent years have seen a surge in scientific interest in nanomaterials, owing to the potential benefits of molecules in the nano-meter range (10-9m). This could be because nanoparticles can alter the properties of molecules with predictable particle sizes and the same chemical composition. According to Nazari & Riahi,

incorporating nanomaterials into concrete specimens has garnered global attention for its potential to improve the durability, mechanical properties, pore structure, and microstructure of cement-based materials. Wang et al., enhanced the effect of NT using a variety of techniques, including the filler material, cement hydration, and parallel packing to form a high-density C-S-H structure.

NT as a novel material NT is one of the most widely used nano-additives in cement-based materials . NT is a non-combustible, odourless powder that has been widely produced and employed in a variety of applications due to its chemical stability, non-toxicity, electrical, and exceptional photocatalytic properties . Brookite, rutile, and anatase are the three distinct phases . Despite the fact that the majority of NT used to date was not in the nano-size state, the usage of NT particles has increased rapidly and is predicted to surpass the use of traditional NT in the next years . The surface area of NT is 500 percent more than that of ordinary NT . It's also possible to get it in a very pure form (99.9 %) .

II. LITERATURE SURVEY & BACKGROUND

The incorporation of nanomaterials in concrete has emerged as a promising area of research within the field of construction materials. Among these nanomaterials, nano-titanium dioxide (Nano-TiO2) has garnered significant attention due to its unique photocatalytic properties, which impart self-cleaning, pollution-reducing, and durability-enhancing characteristics to concrete. This literature review provides a comprehensive overview of the research conducted on the application of Nano-TiO in concrete, focusing on its effects on the mechanical properties, durability, environmental impact, and potential challenges.

Jay Sorathiya, Dr. Siddharth Shah, Mr. Smit Kacha, (2017) research includes an attempt to understand the outcome of Anatase Nano Titanium Dioxide (TiO2) on Conventional Concrete (CC) of M20 grade with various proportions and concluded that the nano-TiO2 particles added concrete had appreciably higher

compressive strength comparable to that of the normal concrete. It is found that the cement could be gainfully added with nano- TiO2 particle up to maximum limit of 1.0% with average particle sizes of 15 nm. (Jay Sorathiya, 2017)

Iyappan. A.P, Srikanthan.L, Felix Franklin.S, Bhuvaneswari.J, Preethika.A, 2017, studied the use of Nano Titanium Dioxide (anatase based TiO2) of size 15 nanometer (nm) to advance the compressive strength and tensile strength of concrete. An experimental study had been carried out by replacing the cement with nano titanium dioxide. The maximum compressive strength and split tensile strength is attained for 1.5% of Titanium Dioxide (TiO2) with replacement of cement (by weight of cement). (Iyappan. A.P, 2017)

III. OBJECTIVE

1. To investigate the fresh and mechanical properties (compressive strength, split tensile strength and flexural strength) at various replacement levels of NT.
2. To study the effect of varying percentage replacement levels of cement with NT particles on durability .

IV RESULT

Effect of NT on Workability

High Surface Area: Nanoparticles like nano-silica (SiO2), nano-alumina (Al2O2), or nano-titanium (TiO2) have an extremely high surface area to volume ratio. This increases the water demand in the mixture because more water is absorbed onto the surface of the nanoparticles.

Table 1 Slump Value variation in concrete with replacement of Cement by NT

SN	Concrete Mix Nomenclature	% OF NT	SLUMP VAUE IN MM
1	NT-0	0	98
2	NT-.5	0.5	85
3	NT-1	1	78
4	NT-1.5	1.5	70
5	NT-2	2	58
6	NT-2.5	2.5	45
7	NT-3	3	38
8	NT-3.5	3.5	32

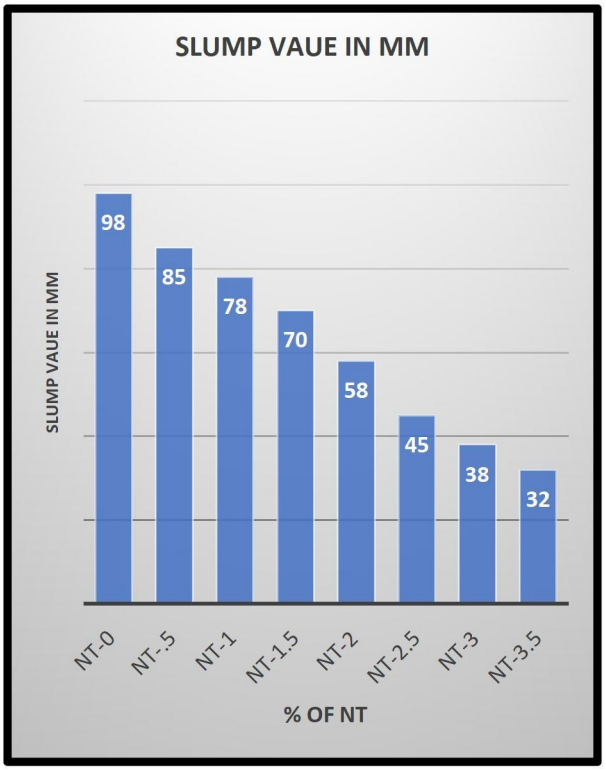

Figure 1 Variation of a slump at the different proportion of NT

4	NT-1.5	1.5	25.8
5	NT-2	2	24.4
6	NT-2.5	2.5	24
7	NT-3	3	23.5
8	NT-3.5	3.5	20.12

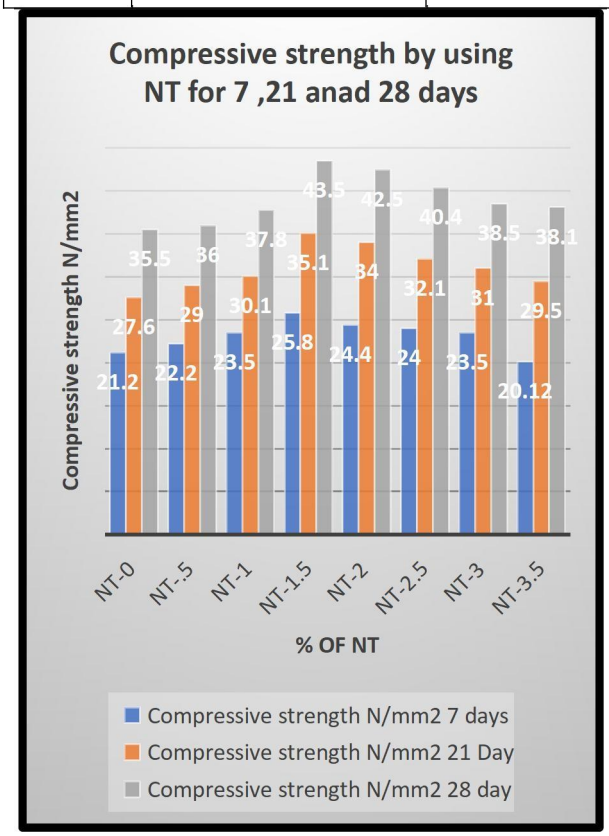

Figure 2 Compressive strength at 7,21,27 days vs percentage replacement of NT and effect of micro filling.

Table 2 Compressive strength by using NT for 7,21,28days

SN	Concrete Mix Nomenclature	% OF NT
1	NT-0	0
2	NT-.5	0.5
3	NT-1	1

At 7 days of age, NT0 compressive strength was tested to be 21.02 MPa. When NT0.5, NT1, and NT1.5 were compared to the control mix (i.e. NT0), the compression strength increased nominally by 2.15 %, 4.15 % and 9.67 % respectively. The strength of NT2 and NT2.5 was determined

to be 6.67 % and 3.34 %, respectively. At 7 days, the strength of NT2.5 was found to be lower than that of the control mix. The maximum gain in compressive strength was found at a replacement level of 1.5 %.

The 28th day split tensile strength improved significantly when compared to the 7th day. When 1.5 % of the cement in concrete was substituted with NT, the split tensile strength rose. The effect of nominal pozzolanic activity of NT and the filler effect could be some of the probable explanations for the improvement in strength up to 1.5 % of NT. The type of cement paste produced and the interfacial transition zone, both of which affect tensile strength, are also influenced by NT properties. Maximum increase in compressive strength was found at 1.5% replacement level. Similar trend was observed in 28,These factor affect compressive strength

Effect of pozzolanic activity: Calcium and silica occurred in NT and increased compressive strength due to pozzolanic activity between NT and water. Both the hydration of Portland cement and the pozzolanic reaction from the NT to the calcium hydroxide part of Portland cement is attributed to the compressive quality of these blends

Effect of chemical reaction: The effect of chemical reaction can be possible in two ways. At the surface level, NT particles can act as nucleation sites and enhance hydration, thereby becoming an integral part of cement paste and contributing to a rich matrix

The two-wall effect: This phenomenon occurs when the amount of water/solution necessary to fill the space between the finer and coarser particles is more than the amount of water/solution contained in the interior of the cement paste. The concentration of anhydrous clinker grains decreases around bigger aggregates . The larger aggregates form a barrier, increasing the concentration of smaller clinker grains near the aggregates. The less dense packing results in a greater water/cement ratio and consequently a more porous paste, reducing the strength in certain places and hence affecting the overall strength of the concrete.

V. CONCLUSION

- Use of NT can improve the compressive strength, split tensile strength, and flexural strength of concrete. This might be ascribed to the nano-filler effect and hydration acceleration effect of NT.
- The compressive strength of a concrete cube specimen of grade M25 with a 1.5 % NT replacement is higher.

Similarly, the split tensile strength of concrete cylinders with 1.5 % NT replacement is higher than that of NT0 concrete.

- As a result of enhanced crystalline Ca(OH)2 amount at the early age of hydration, NT particles as a partial replacement for cement up to 3.5 wt.% could expedite C–S–H gel formation and hence boost flexural and split tensile strengths of concrete specimens even at early ages. Because of the decreased crystalline Ca(OH)2 content necessary for C–S–H gel formation, increased NT particles content of more than 4 wt% produces reduced flexural and split tensile strengths.

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