A LABORATORIAL APPROACH SHOWING SIGNIFICANT CHANGES IN STRENGTH BEHAVIOUR OF CONCRETE ON PERCENTILE SUBSTITUION OF CEMENT WITH NANO TITANIUM DIOXIDE

[1]BASHWAN MANO YASASWI VAVILALA, [2] P. SARDAR KHAN

[1]M. Tech Student, [2]Assistant Professor,
Department of Civil Engineering,
MVR College of Engineering and Technology, Paritala, Andhra Pradesh, India.

Abstract: Nanotechnology has immense potential to result in a new generation of concrete, stronger and more durable, with desired stress-strain behavior and possibly with the whole range of newly introduced properties. Enhanced flexural behavior of the concrete may lead a reduction in the concrete slab thickness used in the construction of concrete pavements. Incorporation of nanomaterials into the matrix to improve concrete mechanical properties has emerged as a promising research field. This paper shows the change in strength behaviour of traditional concrete with substitution of cement with nano titanium dioxide. A nominal mix proportion of required strength is designed with IS 10262:2009 and IS 456:2000. The concrete is mixed with different percentages of titanium dioxide (0%, 0.5%, 1%, 1.5% and 2%) of powder content. In the laboratory, desired concrete was developed and hardened then examined using appropriate testing procedure. Strength behaviour can be analyzed by different tests which require different specimens such as cubes, cylinders and beams for calibrating compressive, split tensile and flexural strength of concrete after 7, 14 and 28 days of curing. After studying the results one percentile replacement of nano titanium dioxide shows maximum strength.

Index Terms **- Cement Concrete, Nano Particles, Titanium Dioxide, Strength Analysis.**

I. INTRODUCTION

Concrete is the mostly used material and the popularity of concrete is due to the fact that common ingredients, the properties of concrete are tailored to meet the demand of any particular application. Concrete is good in compressive strength, durability and stiffness. The main disadvantage is that it is weak in tension and a brittle material. Due to increase in population, high raised building is constructed and for that concrete is very cheapest material for construction. So, regarding its strength it should be strong enough to bear the load. Many researches are done to increase the strength of concrete. Strength of concrete depends on the composition and quality of ingredients. Engineered concrete consist of six components i.e., fine aggregate, coarse aggregate, cement, water, chemical admixture and mineral admixture that also leads to the high performance and ultrahigh performance concrete. The main active constituent of concrete is cement and water that are reactive in nature that binds the fine and coarse aggregate.

Concrete consists of 1-2% of voids that leads to decrement of compressive strength. The voids of mortar in concrete can be filled by using nanoparticles, these nanoparticles can be nano-SiO_2, ZnO nano particles, nanoAl_2O_3, nano-ZrO_2, nano clay and nano-TiO_2 has proven to be very effective for the compressive strength. A number of reports have demonstrated that concrete containing of Titanium Dioxide with Portland cement. Various research has been demonstrated that titanium dioxide is added in relatively small amount to cement significantly improve early resistance of the concrete.

Nano Technology is one of the most active research areas that encompass a number of disciplines, including civil engineering and construction materials. Its applications and advances in concrete materials remain limited. Nanotechnology and nanomaterials offer interesting new opportunities in the construction industry and architecture, for example through the development of very durable, long-lived and at the same time extremely lightweight construction materials. Novel insulation materials with very good insulation values are already available on the market, enable a thermal rehabilitation of buildings in which conventional insulation is not possible, and can help to improve energy efficiency. A wide range of methods for the treatment of surfaces is also available, including glass, masonry, wood or metal; the goal is to improve functionalities as well as extend the lifetime of the materials. Such surface coatings also promise to conserve resources, for example water, energy and cleaning agents. Although the research sector has been reporting intensively about new nanotechnological developments, the reality shows that “nano-products” in the construction industry continue to play a subordinate role and currently merely occupy niche markets. The construction business is considered to be conservative, and innovations often have a difficult time breaking into the market.

Nanotechnology has immense potential and abilities to control the materials world including cement-based materials. Nano concrete is defined as a concrete made with Portland cement particles with sizes ranging from a few nanometres to a maximum of about 100 micrometres. Nano ingredients are ingredients with at least one dimension of nano meter size. Therefore, the particle size has to be reduced in order to obtain nano-Portland cement. If these nano-cement particles can be processed with

nanotubes and reactive nano-size silica particles; conductive, strong, tough, more flexible, cement-based composites can be developed with enhanced properties, for electronic applications and coatings. There is also limited information dealing with the manufacture of nano-cement. If cement with nano-size particles can be manufactured and processed, it will open up a large number of opportunities in the fields of cement-based composites. Current research activity in concrete using nano cement and nano silica includes:

- Characterization of cement hydration
- Influence of the addition of nano-size Titanium Dioxide to concrete
- Synthesis of cement using nano particles and coatings (applied to protect concrete).

A. NANO TITANIUM DIOXIDE

Titanium dioxide nano particles are ultrafine titanium dioxide, titanium's natural oxide. TiO2 is its chemical formula. particles which exist in nature as the notable mineral's rutile, anatase and brookite. The compound Titanium was found in 1791 by William Gregor, in England. Somewhere in the range of 1910 and 1915, the principal licenses were issued for making TiO2. In 1972, Fujishima and Honda found the photo catalytic synergist part of water on TiO2 terminals. At the point when the titanium containing metals have been mined, they should be changed over into pure titanium oxide. Titanium dioxide is the commonly existing oxide of titanium. Its compound equation is TiO2. Titanium dioxide exists in nature as the notable mineral's rutile, anatase and brookite. Titanium dioxide is fundamentally sourced from ilmenite mineral. It is the most far-reaching type of titanium dioxide-bearing metal all around the globe. It is utilized as a fractional trade of bond in concrete for enhancing its quality as far as compressive, flexural and rigidity. Also, the durability can be increased by alleviating quality degrading factors and preventing micro-cracking. But inclusion of TiO2 in concrete reduces workability and exposure to these particles through inhalation; ingestion and dermal penetration to enter the human body could be fatal. Rutile is the steadiest form of titanium dioxide. Anatase and brookite are stable at standard temperatures but on heating gradually converted to rutile.

B. OBJECTIVES OF STUDY

The main objectives of this investigation are:

- Incorporation of nanotechnology into construction technology by substitution in the cementitious materials.
- The progressive efforts going with nanotechnology permits cost effective designs and upgraded concrete execution, which can prompt remarkable uses of concrete.
- Using Nano Titanium Dioxide an innovative fine material, which assumes indispensable part in filling the pores between crystals of concrete.
- Analyzing the strength behaviour of concrete with nano alterations of cement-based materials with nano particles.
- To investigate the strength characteristics of concrete by partial substitution of nano titanium dioxide with 0.5%, 1.0%, 1.5% and 2.0% by weight of cement.
- Analyzing the strength behaviour of concrete for each percentage substitution of titanium dioxide in concrete.

II. MATERIALS AND METHODS

A. CEMENT

Cement is a binder, a material used in construction that strengthens and binds together other materials. The most essential types of cement are used as a component in the manufacture of masonry mortar and concrete. Ordinary Portland cements (53 grades), was used in this project.

The physical properties of cement are listed below in Table 2.1

Table 2.1 Physical properties of cement

No	Properties	Observed value
1	Standard consistency	36%
2	Initial setting time	35 min
3	Specific gravity	3.15

B. FINE AGGREGATE

The fine aggregate used in the making of concrete is natural river sand. Several tests were conducted to examine their properties for the required application, including sieve analysis and fineness module, specific gravity and absorption capacity, moisture content and unit weight as per IS:383- 1970 specification.

The physical properties of fine aggregate are shown in table 2.2

Table 2.2 physical properties of fine aggregate

No	Properties	Observed value
1	Fineness modulus	3.03
2	Specific gravity	2.62
3	Zone of aggregate	Zone II

C. COARSE AGGREGATE

Coarse aggregate is used to make concrete with crushed stone. It's quarried, crushed and graded the commercial stone. A lot of the crushed stone used in granite, calcareous and rock trap. The aggregate is used to refer to basalt, gabbro, diorite and other igneous rocks that are dark- colored, fine-grained. Crushed graded stone is usually just one type of rock and is broken with sharp edges.

The physical properties of coarse aggregate are shown below in table 2.3

Table 2.3 Physical properties of coarse aggregate

No	Properties	Observed value
1	Specific gravity	2.73
2	Nominal size of aggregate	20mm
3	Fineness modulus	6.67%

D. TITANIUM DIOXIDE

The properties of titanium dioxide are shown below in table 2.4

Table 2.4 Properties of TiO_2

No	Properties	Observed value
1	Appearance	White
2	Odour	No
3	Specific gravity	4.26
4	Density	3.82g/cc

E. MIX DESIGN VALUES

The mix proportions for M35 grade concrete were obtained as per IS 10262:2009 is given by table 2.5.

Table 2.5 Mix Proportion for M35 grade

Cement kg/m^3	Fine aggregate kg/m^3	Coarse aggregate kg/m^3	Water kg/m^3
400	655.11	1133	172.68
1	1.56	2.90	0.43

III. METHODOLOGY OF EXPERIMENT

In this investigation, test cubes, cylinders and beams were conducted. The step-by-step experimental work is as follows:

- Material collection such as cement, fine aggregate, coarse aggregate and titanium dioxide were brought.
- The M35-grade concrete mix design was calculated using standard Indian codes.
- According to mix design, batching and weighing of materials was done.
- The fresh concrete test (slump cone test) was performed and the ratio of water cement was found.
- The sample such as cube and cylinders were prepared and the materials were casted into the respective moulds.
- The beam mould is prepared and it is also casted using the mix proportions.
- The moulds are removed and the sample in the water tank was healed.
- Hardened concrete tests such as compressive strength test, split tensile strength test and flexural strength test have been found after 28days of curing.

IV. EXPERIMENTATION AND RESULTS

A. COMPRESSIVE STRENGTH TEST

Compressive strength test is an important parameter to determine the performance of material during several weather conditions. Here, concrete mix of M35 grade is made with various proportions of titanium dioxide such as 0.5%, 1%, 1.5% and 2%. The size of concrete cube moulds are 15cm×15cm×15cm.Concrete cube specimens are made and cured for 28days

Table 4.1 Compressive strength value

S.No	Type of Concrete	At 7days (N/mm^2)	At 28days (N/mm^2)
1	Normal Concrete	23.5	43.25
2	0.5%TiO_2	32.14	49.46
3	1% TiO_2	34.08	52.32
4	1.5%TiO_2	**38.76**	**59.64**
5	2%TiO_2	30.92	47.54

B. SPLIT TENSILE STRENGTH TEST

Similar to compressive strength test of cube specimens split tensile strength test is done. Here, concrete mix of M35 grade is made with various proportions of titanium dioxide such as 0.5%, 1%, 1.5% and 2%. Samples of the cylinder are placed horizontally and testing is carried out. Using compressive testing machine, it is also tested.

Table 4.2 Split Tensile Strength Values

S.No	Type of Concrete	At 7days (N/mm^2)	At 28days (N/mm^2)
1	Normal Concrete	1.96	3.02
2	0.5%TiO_2	2.24	3.46
3	1% TiO_2	2.52	3.85
4	1.5%TiO_2	**2.67**	**4.12**
5	2%TiO_2	2.35	3.62

C. FLEXURAL STRENGTH TEST

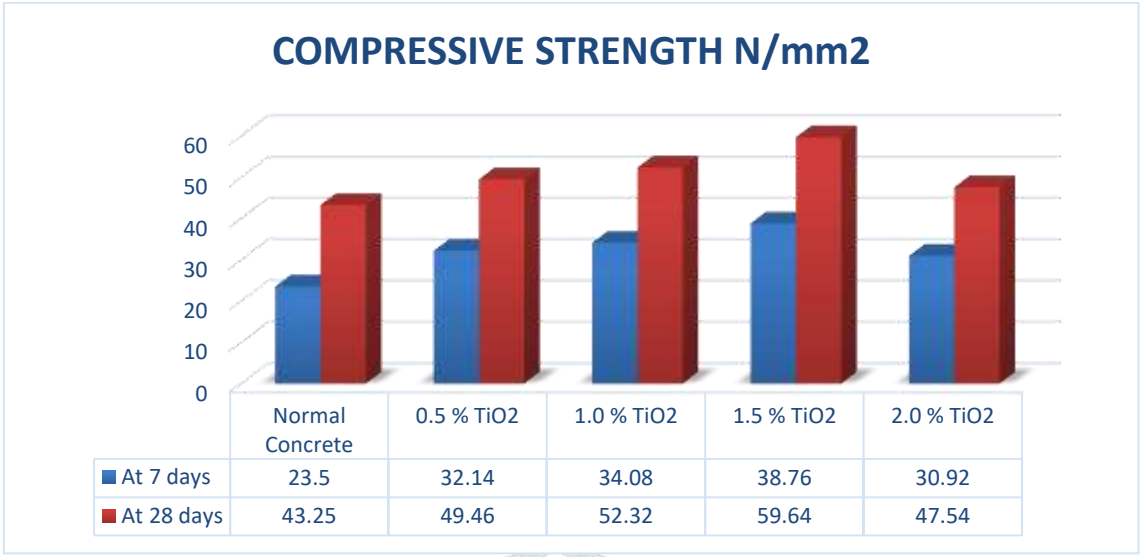
Flexural strength is the amount of force an object can take without permanently breaking or deforming. The beams are made, one with conventional concrete and other beam with 1.5%replacement of titanium dioxide. The beam is being healed and tested.

Table 4.3 Flexural strength test

S.No	Type of Concrete	At 7days (N/mm^2)	At 28days (N/mm^2)
1	Normal Concrete	4.34	5.49
2	0.5%TiO_2	4.89	6.21
3	1% TiO_2	5.58	7.02
4	1.5%TiO_2	**6.24**	**7.82**
5	2%TiO_2	5.76	7.39

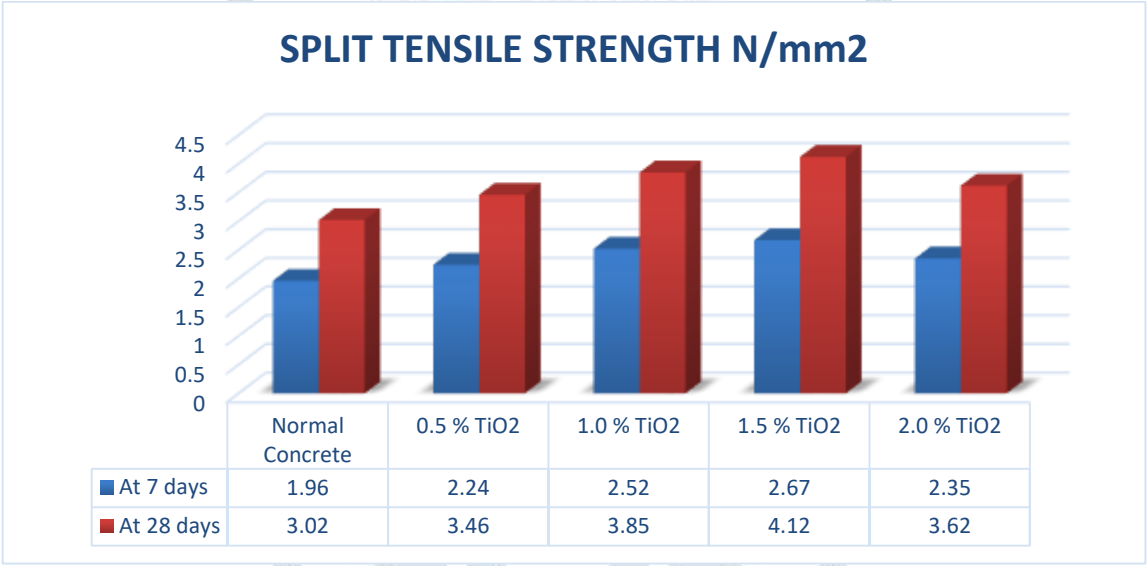
D. GRAPHS FOR THE OBTAINED TEST RESULTS

Graph 1: Compressive Strength Test Results



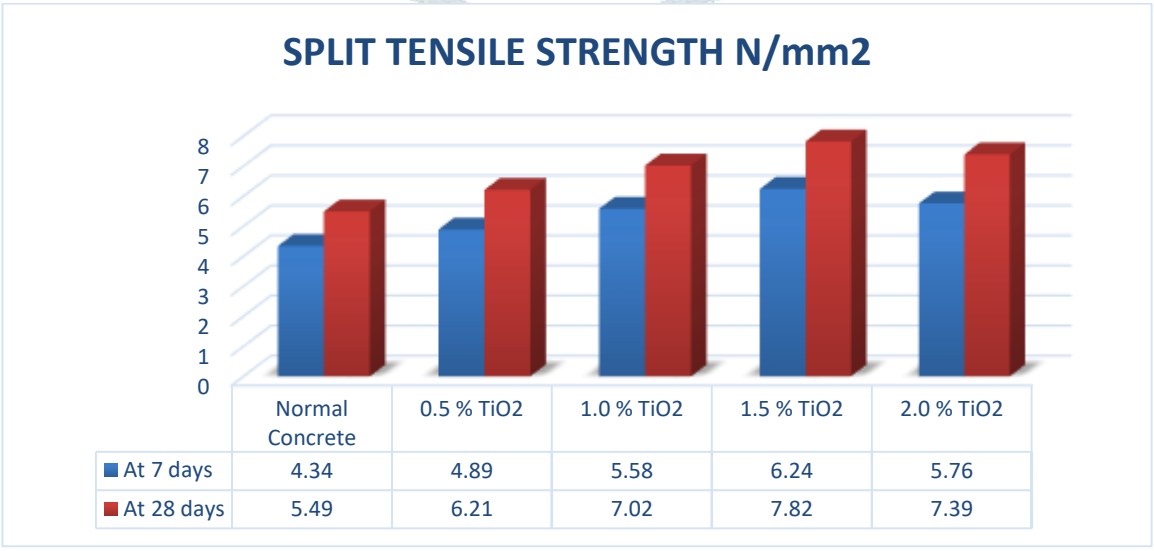
	Normal Concrete	0.5 % TiO2	1.0 % TiO2	1.5 % TiO2	2.0 % TiO2
At 7 days	23.5	32.14	34.08	38.76	30.92
At 28 days	43.25	49.46	52.32	59.64	47.54

Graph 2: Split Tensile Strength Test Results



	Normal Concrete	0.5 % TiO2	1.0 % TiO2	1.5 % TiO2	2.0 % TiO2
At 7 days	1.96	2.24	2.52	2.67	2.35
At 28 days	3.02	3.46	3.85	4.12	3.62

Graph 3: Flexural Strength Test Results



	Normal Concrete	0.5 % TiO2	1.0 % TiO2	1.5 % TiO2	2.0 % TiO2
At 7 days	4.34	4.89	5.58	6.24	5.76
At 28 days	5.49	6.21	7.02	7.82	7.39

V. CONCLUSIONS

The study concludes that the addition of Nano TiO2 in the concrete mixture behaves not only as a filler to improve the microstructure, but also as an activator to promote pozzolanic reaction thereby resulting in the enhancement of the durability and mechanical properties of the mix. Titanium dioxide used in this experimental work is **rutile** base having particle size 20nm.

From the study, the following were concluded;

- The optimum quantity of TiO2 can be used in the concrete to gain augmented strength parameters by utilizing as filler or replacing part of cement and also in order to improve the performances of concrete properties.
- The concrete cube specimen of grade M35 with a 1.5% replacement of TiO_2 provides a higher compressive strength. The value was **59.64 N/mm^2** after 28 days of curing.
- Similarly, concrete cylinder split tensile strength with 1.5% replacement of TiO_2 shows a higher value compared to conventional concrete. The value was **4.12 N/mm^2** after 28 days of curing.
- Similarly, concrete Flexural strength with 1.5% replacement of TiO_2 shows a higher value compared to conventional concrete. The value was **7.82 N/mm^2** after 28 days of curing.
- The values have been gradually increased at 0.5%, 1%, 1.5% replacement of titanium dioxide and at 2% of replacement the value decreases.
- As the value of concrete cubes and cylinder increases by 1.5 % replacement of TiO_2, the flexural strength of the beam was found for 1.5 % replacement of TiO_2.
- Hence the use of smaller percentage of titanium dioxide gives the valuable results.

REFERENCES

IS CODES:

1. Indian Standard Code for Practice for Plain Cement Concrete IS 456:2000.
2. Indian Standard Concrete Mix Proportioning Guidelines, IS 10262:2009
3. Method of Tests for Strength of Concrete, IS 516:1959.
4. Specifications for Coarse and Fine Aggregates from Natural Sources for Concrete, IS 383:1970.

[1] Akhil Teja Perumalla, Srinivas Eera , An Experimental Study On Strength Characteristics By Partial Substitution Of Cement With Nano Titanium Dioxide, International Research Journal of Engineering and Technology Volume: 07 Issue: 07 | July 2020.

[2] Dr.R.Umamaheswari, S.Monisha, Experimental Investigation Of Concrete Using Titanium Dioxide, International Research Journal Of Engineering And Technology Volume: 06 Issue: 05 | May 2019.

[3] Shivanshu Mishra, Archana Tiwari, Effect on Flexural Strength of Concrete by Addition of Nano Titanium Dioxide and Nano Calcium Carbonate, International Journal of Science and Research Volume 7 Issue 3, March 2018.

[4] Abhishek Singh Kushwaha, Rachit Saxena, Shilpa Pal, Effect of Titanium Dioxide on the Compressive Strength of Concrete, Journal of Civil Engineering and Environmental Technology Volume 2, Number 6; April-June, 2015

[5] Alaa M. Rashad, A Synopsis About the Effect of Nano-Titanium Dioxide on Some Properties of Cementitious Materials