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Effect of Titanium Dioxide on the Compressive Strength of Concrete

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Abstract—This paper presents the experimental study on the Effect of titanium dioxide on the compressive strength of concrete. For the experimental study M30 grade of concrete is casted and cement is partially replaced by titanium dioxide (by weight). The amount of titanium dioxide is varied from 1% to 3% in cement. Titanium dioxide act as the nanoparticles that fills the nano voids in concrete that leads to the increment of compressive strength. And this study shows that the 1% of titanium dioxide is optimum for compressive strength of concrete further increment of titanium dioxide decreases the compressive strength of concrete. The mix. Design of M30 is done by IS 10262:2009 and IS 456:2000. The size particle of titanium dioxide is varying from 20µm to 25µm were used. The test were carried through compression testing machine and all the results are compared to control specimen of M30.

1. 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 are 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 consist 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 [1]. A number of reports have demonstrated that concrete containing of Titanium Dioxide with Portland cement. Various research have been demonstrated that titanium dioxide is added in relatively small amount to cement significantly improve early resistance of the concrete [5].

The element Titanium was discovered in 1791 by *William Gregor*, in England. . Between 1910 and 1915, the first patents were issued for making TiO2. In 1972, *Fujishima* and *Honda* discovered the photo catalytic splitting of water on TiO2 electrodes. When the titanium containing ores have been mined, they need to be converted into pure titanium oxide. The two main production methods are the *sulfate process* and the *chloride process* [5].

When TiO2 nanoparticles with the average particle size of 15 nm were partially added to concrete with the optimum content of ground granulated blast furnace slag and physical and mechanical properties of the specimens were measured. TiO2 nanoparticle as a partial replacement of cement up to 3wt% could accelerate C-S-H gel formation as a result of increased crystalline Ca(OH)2 amount at the early age of hydration and hence increase compressive strength of concrete [2].

The three common phases of titanium dioxide are *rutile*, *anatase* and *brookite*. Rutile is the most stable form of titanium dioxide. Anatase and brookite are stable at normal temperatures but slowly convert to rutile upon heating[5]. In this study the anatase based TiO_2 is used because in previous study rutile based TiO_2 was used. Application of titanium dioxide can be used in various fields such as it has a wide range of applications, from paint, sunscreen to food colorings. It is used for water and air purification has been a subject of extensive research. More recent, the applications have widened to surfaces with self-cleaning, self-sterilizing, bactericidal and anti-fog properties [6]. It also increases the compressive strength of concrete. The incorporation of 0.5wt% of TiO2 (rutile based) reduces the flexural and

compression strength. Increasing amounts up to 2.5wt% does not cause significant modifications in the flexural strength or the compressive strength. A quantity greater than 2.5wt% affects the mechanical properties however the 5wt% results are close to the 0.5wt% values[3].

TiO2 nanoparticles decreased the compressive strength after 28 days of curing; however, the permeability of concrete was lowered [4]. Besides, with increase in percentage of the ZnO nanoparticles in concrete mixture, the lower compressive strength was obtained.[4]

2. EXPERIMENTAL STUDY

The main work of this experiment is to fabricate the M30 grade of concrete i.e. control mix of M30 is prepared and concrete cubes containing titanium dioxide with variation of 1% to 3% are casted. After 3, 7 and 28 days the compressive strength of these cubes were compared to control mix of M30 grade.

2.1 Test Materials

Cement OPC 43 grade, water, fine and coarse aggregate, admixture Aura mix 400 (used for workability), titanium dioxide (Anatase based) having particle size 20-25µm.

Cement – Ordinary Portland Cement (OPC) of 43 Grade (Bangur Cement) is used that is locally available. The cement was free from lumps. The properties of the cement as determined from various test confirming to IS: 8112-1989.

Fine Aggregate: Natural sand of grading Zone II confirming to IS:383-1970 is used that is available commercially. The specific gravity of the sand is calculated as 2.70.

Coarse Aggregate: Crushed angular coarse aggregates of 10mm and 20mm nominal sizes are used as per IS:383-1970. The specific gravity of the aggregate is 2.69.

Chemical Admixture: A concrete super plasticizer was used from Fosroc Chemicals (India) Pvt. Ltd. as shown in (Fig. 1) to reduce the water Cement ratio.

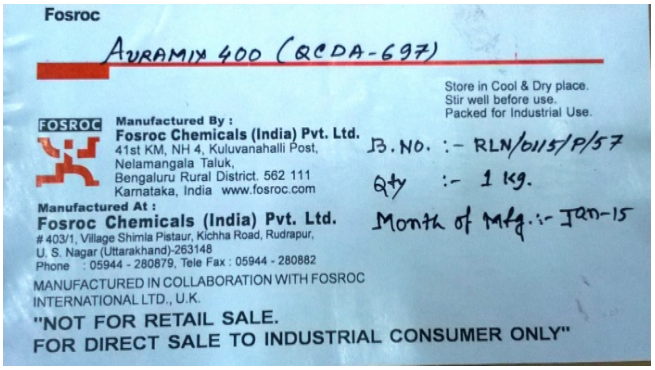


Fig. 1: Superplasticizer (Fosroc)

Titanium Dioxide

Particulars	Anatase based
TiO2	97-98 %
Specific Gravity	3.8-3.9
pH Content	6.5 – 8
Moisture	0.4% max
Oil Absorption	20 - 25 gm / 100 gm
Particle size	20-25µm

Fig. 2: Titanium Dioxide (Anatase Based)

2.2 Concrete Mix Design M30

Water cement ratio	0.42
Cement content	376.2 kg
Volume of all in aggregate	0.718m^3
Mass of C.A.	1197.4 kg
Mass of F.A.	711.6kg

Concrete mix is carried out using Indian Standard Code IS 456:2000, IS 10262:2009 and some codes like IS 2386: (part 3) 1963 is used for methods of test for aggregates for concrete.

3. TEST PROCEDURE

In order to accomplish the aims and objective of the present study the following experiments are done. The purpose of doing the experiment is to compare the properties of different grade of concrete to concrete which is having partially replaced cement by titanium dioxide. The main objective of doing this experiment is to find the effects of titanium dioxide on properties of concrete. The study is done on M30 grade of concrete and conclusions are made. Standard size of each cube is 150mm x 150mm x 150mm.

3.1 Casting of Cubes

For dimensionally accurate cubes of size 150 x 150 x 150 mm^3, 36 cubes were made as per IS 10262: 2009 and IS 456: 2000. The molds were cleaned and oiled before casting. Before commencement of casting of cubes proper mix is prepared in grinding mixture.

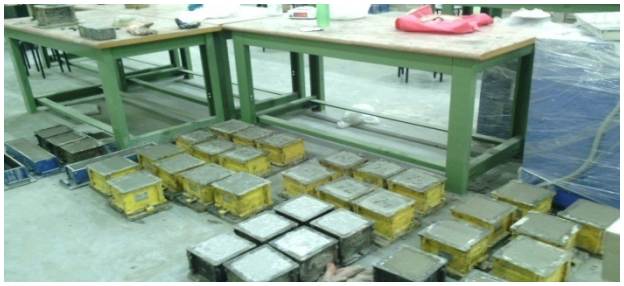


Fig. 3: Casting of Cubes

3.2 Demoulding the Test Cubes

Test cubes should be demoulded between 16 and 24 hours after they have been made. If after this period of time the concrete has not achieved sufficient strength to enable demoulding without damaging the cube then the demoulding should be delayed for a further 24 hours. When removing the concrete cube from the mold, take the mold apart completely.

Fig. 4: Demoulding the Test Cubes

After demoulding, each cube should be marked with a legible identification on the top or bottom using a waterproof crayon or ink. The mold must be thoroughly cleaned after demoulding the cube. Ensure that grease or dirt does not collect between the faces of the flanges, otherwise the two halves will not fit together properly.

3.3 Curing of cubes

Cubes must be cured before they are tested. Unless required for test at 24 hours, the cube should be placed immediately after demoulding in the curing tank or mist room.

Fig. 5: Curing of cubes

The curing temperature of the water in the curing tank should be maintained at 27-30°C. If curing is in a mist room, the relative humidity should be maintained at no less than 95%. Curing should be continued as long as possible up to the time of testing. In order to provide adequate circulation of water, adequate space should be provided between the cubes, and between the cubes and the side of the curing tank. If curing is in a mist room, there should be sufficient space between cubes to ensure that all surfaces of the cubes are moist at all times.

3.3 Testing of Cubes

The specimens are tested by compression testing machine after 7 days curing or 28 days curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

Fig. 6: Testing of Cubes

Minimum three specimens should be tested at each selected age. If strength of any specimen varies by more than 15 per cent of average strength, results of such specimen should be rejected. Average of their specimens gives the crushing strength of concrete. The strength requirements of concrete.

4. RESULTS

Compressive strength of concrete, Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. Test result for M30

control mix can be observed in table 1. Similarly refer table 2 for 1% replacement of cement by titanium dioxide, table 3 for 2% replacement and table 4 for 3% replacement of cement by titanium dioxide. The compression testing of cubes samples were tested in 3, 7 and 28 days. The compressive strength of concrete can be calculated by the ratio of load applied on one cube to the area of one face of cube i.e. (150mm x 150mm). Due to small size titanium dioxide it fill the voids of mortar of concrete which leads in increase of strength, excess amount titanium dioxide covers the cement particles which disrupts the water cement reaction and hence the strength decreases on further increment.

4.1 Table 1

Grade	3Day Strength	7Day Strength	28 Day Strength
M30	5.86 N/mm^2	23.12 N/mm^2	34.58N/mm^2

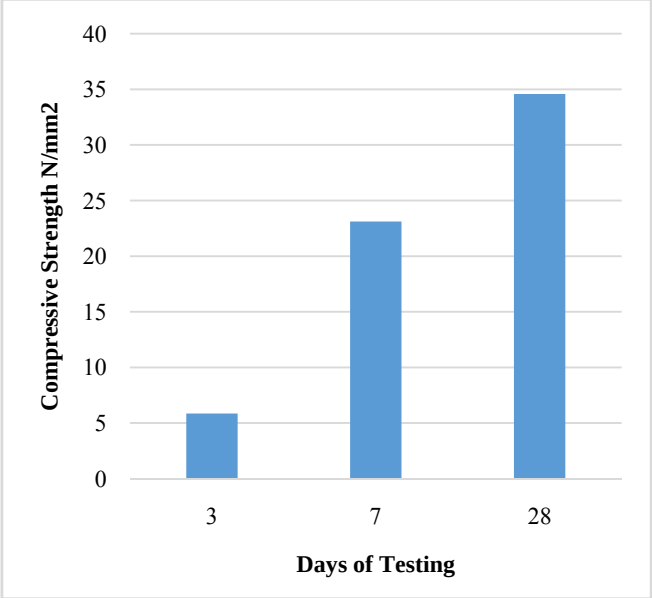


Fig. 7: Graph of M30 Control Mix

4.2 Table 2

Grade	3Day Strength	7Day Strength	28 Day Strength
M30	7.46 N/mm^2	30.25N/mm^2	48.05N/mm^2

***Fig. 7*: Graph of M30 (1% Replacement of cement)**

4.3 Table 3

Grade	3Day Strength	7Day Strength	28 Day Strength
M30	7.83 N/mm^2	29.33N/mm^2	43.22N/mm^2

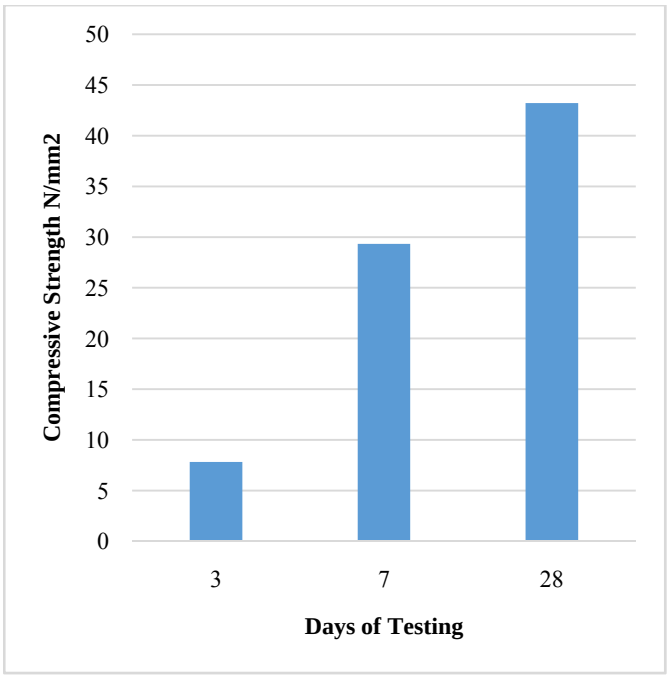
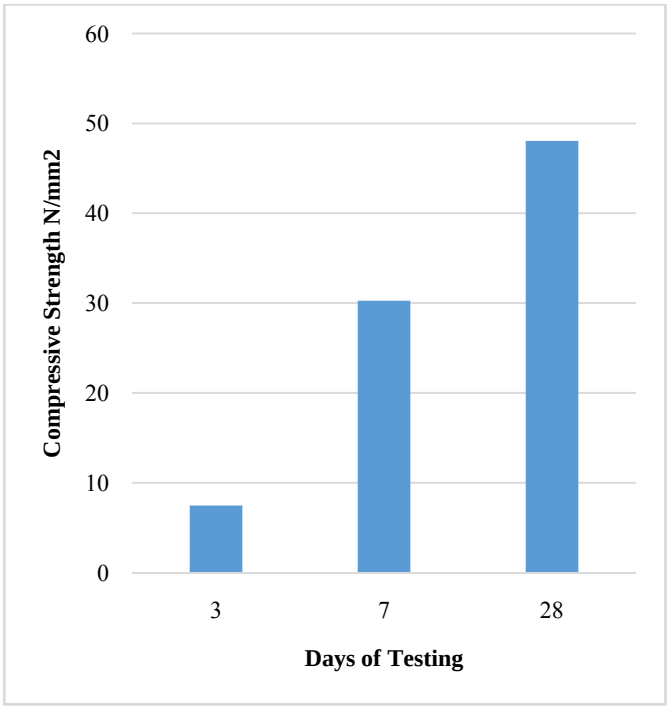


Fig. 8: Graph of M30 (2% Replacement of cement)

4.4 Table 4

Grade	3Day Strength	7Day Strength	28 Day Strength
M30	7.90 N/mm^2	25.67 N/mm^2	40.41N/mm^2



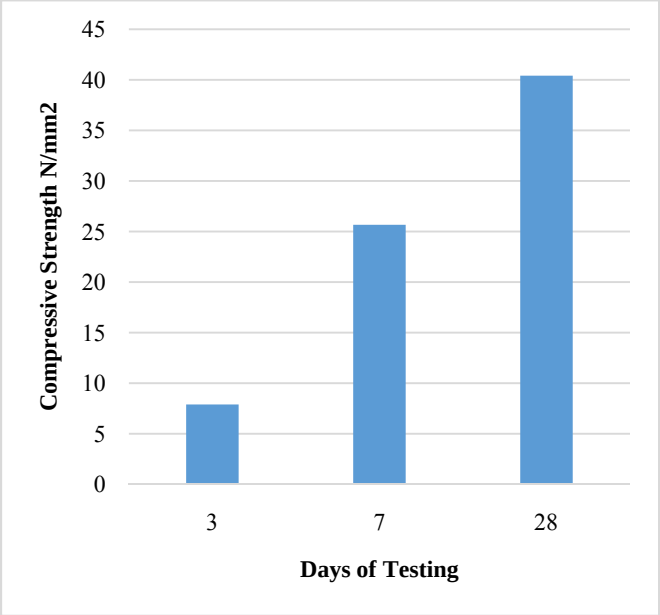


Fig. 9: Graph of M30 (3% Replacement of cement)

4.5 Comparison of Compressive Strength

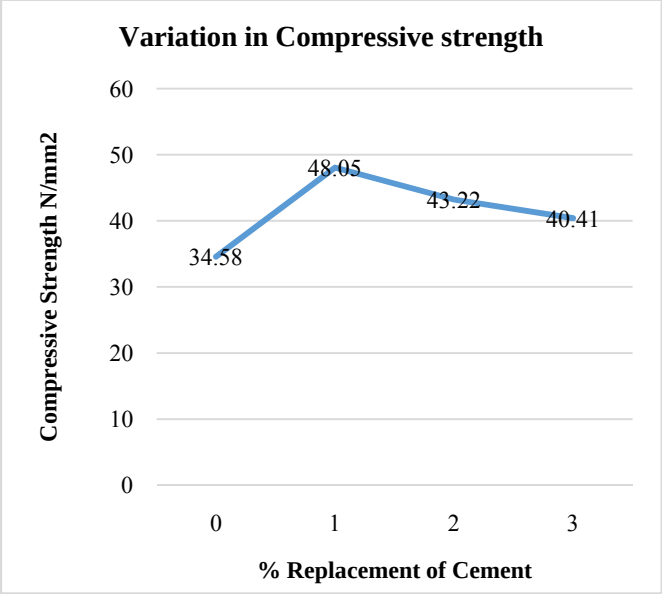


Fig. 10: Graph of M30 (28 Days Strength Comparison)

5. CONCLUSION

The compressive strength has been increased by the 1% replacement of cement by titanium dioxide and further strength decreases on increment of titanium dioxide. Titanium dioxide used in this experimental work is anatase base having particles size 20-25µm.Further study can be extended on various properties of concrete by changing the particles size of titanium dioxide and various grade of concrete.

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REFERENCES

[1] Florence Sanchez & Konstantin Sobolev "Nanotechnology In Concrete"(2010)
[2] Nazari Ali & Riahi Shadi "TiO_2 Nanoparticles Effects on Properties of Concrete Using Ground Granulated Blast Furnace Slag as Binder"(2011)
[3] SS Lucas, VM Ferreira, JL de Aguiar" Incorporation of Titanium Dioxide Nanoparticles in Mortar, Influence of Microstructure in The Hardened State Properties and Photo catalytic Activity"(September 2012).
[4] K. Behfarnia and A. Keivan "The Effects of TiO_2 and ZnO Nanoparticles on Physical Mechanical Properties of Normal Concrete" (2013)
[5] Amy L. Linsebigler, Guangquan Lu, and John T. Yates, Jr. "Photocatalysis on TiOn Surfaces: Principles, Mechanisms, and Selected result" (1995)
[6] Anne Beeldens "An environmental friendly solution for air purification and self-cleaning effect: the application of TiO_2 as photocatalyst in concrete" [2006]
[7] IS 10262: 2009 "Concrete Mix Proportioning"
[8] IS 456: 2000 "Plain and Reinforced Concrete"
[9] IS 2386 Part1 1963 "Methods of Test for Aggregate for Concrete"
[10] IS 9103: 1999 "Specification for Admixture for Concrete"
[11] IS: 383-1970: Specification for Coarse and Fine Aggregates from Natural Sources for Concrete, Bureau of Indian Standards, New Delhi, 1993.
[12] IS: 8112-1989: Specification for 43-grade Ordinary Portland Cement, Bureau of Indian Standards, New Delhi. 2001.