GSJ: Volume 10, Issue 1, January 2022, Online: ISSN 2320-9186

www.globalscientificjournal.com

Utilization Of Self-Cleaning Concrete Containing Titanium Dioxide

Abubakar[1], Qasim Zeb[2], Yaseen Kamal[3], Usama Asghar[4], Adeed Khan[5]

[1,2,3,4,5]Iqra *National University, Peshawar, Pakistan*

Abstract

In the field of construction, concrete is the frequently used material. Cement production, on the other hand, releases significant amounts of carbon dioxide (CO_2) into the atmosphere, contributing to global warming. As a result, a market for environmentally friendly manufacturing materials like self-cleaning concrete has emerged. Self-cleaning concrete is made with a more environmentally friendly binder, which is a revolutionary manufacturing fabric that replaces Portland cement. The inclusion of photocatalytic materials such as titanium dioxide (TiO_2) and zinc oxide (ZnO) enhance the concrete's self-cleaning abilities. UV rays could be used to power self-cleaning concrete incorporating photocatalysts, accelerating the decomposition of organic particles. As a result, the regular cleaning of building facades can be conserved, and dangerous gases in the environment can be reduced. This examination displays the results of an experimental investigation of titanium dioxide-containing concrete. The investigation's main purpose is to improve the hardness and strength of concrete structures. A very small amount of titanium dioxide is used to achieve the positive effects (TiO_2). A one-of-a-kind titanium dioxide powder content is used to produce the concrete (0 percent, 7 percent, 10 percent, 13 percent). The proportions of the M15-grade concrete mixture were carefully calculated. The cylinders and beams in the samples have been cast and cured. Break up tensile strength, compressive strength, and flexural strength of hardened concrete were tested experimentally after 14, and 28 days of curing. The highest strength was reached with titanium dioxide (TiO_2) supplementation of 7%, 10%, and 13% by weight of cement, respectively.

Keywords: Self-Cleaning Concrete, Titanium Dioxide, Strength

I. Introduction

Housing is widely acknowledged as one of civilization's most important need. Humans addressed their demands in naturalistic habitats such as caves and rock shelters before the construction of dwellings for protection. People's social, physiological, mental, and economic development, as well as technological advancements, have enabled civilization to progress to the point where houses may be erected. Despite the fact that materials like as pozzolanic ash were employed by Ancient Rome and potentially even earlier empires, no material growth was visible until the 18th century with the rise of the need for structural material in home construction. Despite the fact that extensive works on cement and reinforced concrete were published in the early 1800s, concrete was not widely used until the early 1900s.

Self-cleaning concrete has the potential to reduce pollution in cities [1]. Nitrogen oxides (NO), carbon dioxide (CO2), and other atmospheric gases are not only dangerous to one's health, but they also cause damage to many concrete structures. This research aims to reduce emissions by combining cleaner air technologies, such as photo catalyst, a method of eliminating hazardous pollutants from the atmosphere, into the design of a low-cost local building panel system that is suitable for their various environmental conditions [1]. Food, as well as other commodities and services, include TiO2. TiO2 treated materials have become increasingly common in recent years [2]. Houses have been shown to have a lot of big particles. From chook poo to automotive pollution, all metropolitan structures are frequently

exposed to organic fibre that makes their surfaces seem filthy. Poisonous substances, on the other hand, are a form of biological material that is continually hitting dwellings and hence more difficult to spot (nitrogen oxides). As the primary cause of smog, nox not only pollutes the environment around our homes, but it also degrades the air quality of the inside environment we breathe [3].

Fig. Effect of pollution [3]

II. Literature Review

He studied the photo catalytic potential and long-term viability of $Ti0_2$-containing cementitious materials used to recover organic wastes. Following that, researchers looked at the production, microstructure, permeability, photo catalytic characteristics, and workability of TiO2-containing cement-based materials. The TiO2 nanoparticles are equally spread over the cement compositions' surface. The study observed that soaking concrete components in acidic or alkali solutions for extended periods of time improves efficiency. For photo catalytic cement mortars, high predictive performance was attained, with a disintegration rate of more than 93 percent for 20 cycles. Photo catalytic cement mortars have been demonstrated to have high water permeability, chloride penetration resistance, and carbonation resistance when it comes to durability. Water absorption, chloride electric flux, chloride penetration, and photo catalytic TiO2 carbonation of cement mortars exceeded carbonation of extremely pure cement mortars. [4].

Nazari et al. looked at the effects of using limewater as a curing environment for TiO_2 enhanced concrete. At 0.5, 1.0, 1.5, and 2.0 weight percent, the TiO_2 particles are simply replaced in part by cement. The mixed concrete with TiO_2 particles with a diameter of around 15 nm had a higher flexural strength than the CC, according to the findings. Furthermore, for curing durations of 7, 28, and 90 days, the optimal TiO_2 replacement ratio was reported to be 1%. The findings of the experimental testing revealed a significant reduction in the percentage of water absorption and permeability at all stages when TiO_2 particles were used. [5]. The goal of this experiment is to look into the compressive strength and self-cleaning qualities of concrete utilising nano-liquid TiO2 applications on various concrete values (0, 2.5, 5.0, 7.5 ml) and mono, double, and triple-layered Nano-liquid TiO2 coatings on hardened concrete. Cement was partially replaced with fly ash. The self-cleaning capabilities of concrete were investigated using a Rhoda mine-B dye (RhB) discoloration test and visual observation under sunlight/UV light in this study. Cement was replaced with 30% fly ash, and the self-cleaning capabilities of concrete were investigated using a Rhoda mine-B dye (RhB) discoloration test and visual observation under sunlight/UV light. Concrete samples containing photo catalytic Nano-liquid Tio2 mixed with fresh concrete (NF) revealed higher compression strength when compared to Nano-liquid Tio2 sprayed on the surface of the concrete (NH). The capacity of NH samples to clean was shown to be superior to that of NF samples [6].

III. Experimental Procedure

MIX Design:

The Mix design was done for self-cleaning concrete and the data is given in below table.

Table: The mix proportions for M15 grade concrete were obtained as per IS code.

TiO2%	TiO2 (kg)	Water (ml)	Weight of Cement (kg)	Weight of sand(kg)	Weight of C.A(kg)	Total weight (Kg)	No of cylinders	No of beam
0%	0	7500	15	30	60	105	4	2
7%	1.05	6975	13.95	30	60	103.95	4	2
10%	1.5	6750	13.5	30	60	103.5	4	2
13%	1.95	6525	13.05	30	60	103.05	4	2

Casting of concrete cylindrical specimens:

For compressive strength of concrete, ASTM (C469) standard cylindrical concrete specimens with a diameter of 6 inches and a length of 12 inches (6" x 12") were casted. Concrete cylinders were filled in three levels and carefully consolidated to eliminate air entrapped after correct mixing. In this example, the result was achieved using M15 grade concrete with a 1:2:4 mix ratio.

Fig. Compressive Test Samples

Casting of concrete split tensile specimens:

For split tensile strength of concrete, ASTM (C469) standard split tensile concrete specimens with a diameter of 6 inches and a length of 12 inches (6" x 12") were casted. The concrete elements are mixed in a straightforward manner, and TiO_2 powder is also added to the concrete. Concrete cylinders were filled in three levels and carefully consolidated to eliminate air entrapped after correct mixing. In this example, the result was achieved using M15 grade concrete with a 1:2:4 mix ratio.

Fig. Split tensile test samples

Casting of concrete Beam for flexure strength:

To test the flexure strength of concrete, 4" x 4" x 12" concrete beam specimens were produced. After 14 days and 28 days of total maturity, a concrete prism specimen was cast, cured, and tested. The tests were performed on M15 grade concrete with a 1:2:4 concrete mix ratio.

Fig. Flexural test specimens

Curing of specimens:

Curing is the process of keeping concrete moist in order for it to reach full strength. Following the casting of concrete, the specimens were lifted in moulds for 24 hours, then removed from moulds and placed in a container holding impurity-free water for 14 and 28 days of curing, as indicated in the figure.

Fig. Curing of specimens

IV. Result and Discussion

Compressive strength test:

The compressive strength test is an essential measure for determining a material's performance under various weather conditions. In this case, a concrete mix of M15 grade is prepared using varying quantities of titanium dioxide, such as 7%, 10%, and 13%. The concrete cylinder's diameter is (6”x12”). Concrete cylinder specimens are created and left to cure for 14 and 28 days, respectively.

Fig. Compressive strength test

It has been discovered that when TiO_2 is added to concrete, the compressive strength increases by 7%. The compressive strength of TiO_2 diminishes after 7%. The compressive strength of various percentages of titanium dioxide is shown in the table.

Table Compressive strength

S NO	% of Titanium dioxide (TiO_2)	Compressive strength (mpa)		Compressive strength in (psi)	
		14 days	28 days	14 days	28 days
1	0%	14.9	21.48	2161	3115

2	7%	14	20.5	2030	2973
3	10%	13.35	19.8	1936	2871
4	13%	12.5	18.8	1812	2726

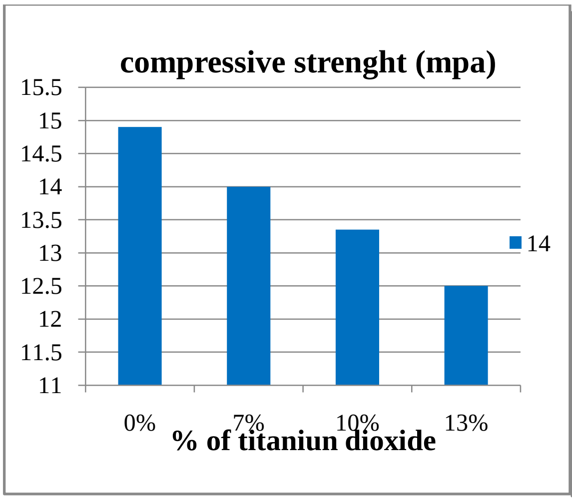

Fig. 14 days Compressive strength

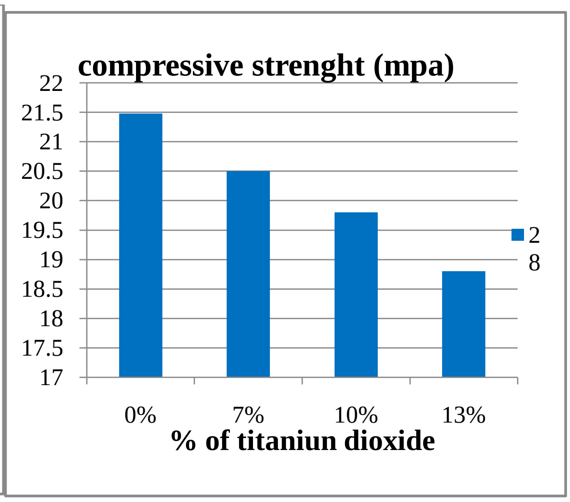

Fig. 28 days Compressive strength

Split tensile strength test:

Split tensile strength tests are performed similarly to compressive strength tests on cylinder specimens. The concrete mix for M15 grade is created with different quantities of titanium dioxide, such as 7%, 10%, and 13%. The cylinder samples are arranged horizontally, and testing is performed.

Fig. Split tensile test

Using compressive testing machine, it is also tested. Table shows the split tensile strength of various percentage of titanium dioxide.

Table Split tensile strength

S NO	% of Titanium dioxide (TiO2)	Split tensile strength (mpa)		Split tensile strength in (psi)	
		14 days	28 days	14 days	28 days
1	0%	2.72	3.76	394	545
2	7%	2.55	3.59	369	520
3	10%	2.34	3.42	339	496
4	13%	2.24	3.27	324	474

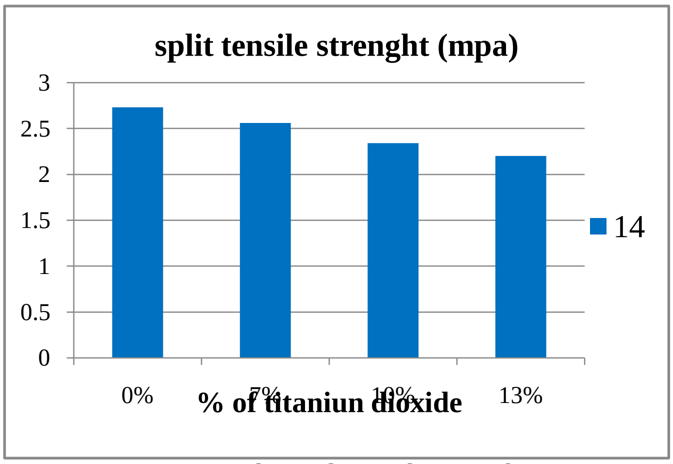

Fig. 14 days split tensile strength

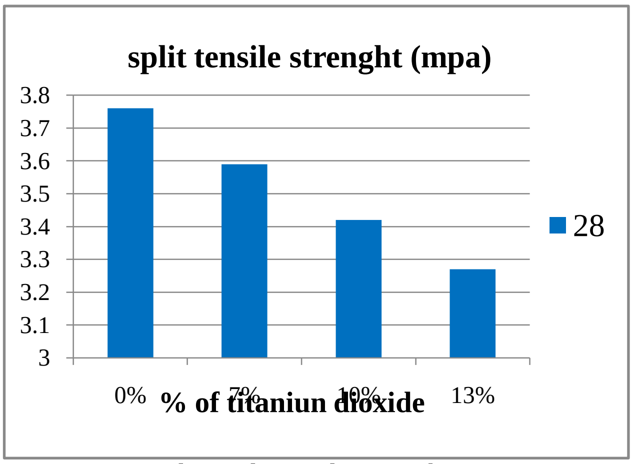

Fig. 28 days split tensile strength

Flexural strength test:

The amount of force that an item can withstand without breaking or deforming is known as flexural strength. Various quantities of titanium dioxide, such as 7%, 10%, and 13%, are used in this concrete mix of M15 grade. The beam's dimensions are (4”x4”x12”). 14 and 28-day concrete flexural specimens are made and cured. The beam is currently being cured and put through its paces.

Fig. Flexural strength

Table below shows the flexural strength of various percentage of titanium dioxide.

Table Flexural strength

S NO	% of Titanium dioxide (TiO2)	Split tensile strength (mpa)		Split tensile strength in (psi)	
		14 days	28 days	14 days	28 days
1	0%	1.12	1.28	162	185
2	7%	1.09	1.26	158	182
3	10%	1.07	1.23	155	178
4	13%	1.05	1.19	152	172

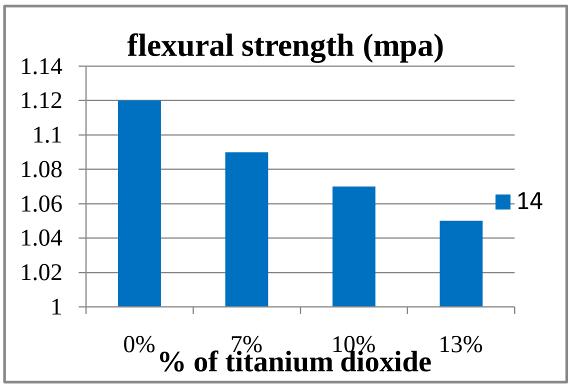

Fig. 14 days flexural strength

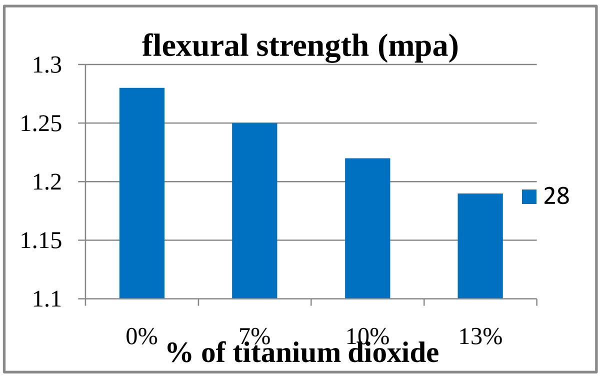

Fig. 28 days flexural strength

V. Conclusion

Based on the results and analysis, the following conclusions have been arrived.

- The compressive strength of a concrete cylinder specimen of grade M15 with a 7% TiO_2 substitution is greater.
- Similarly, the split tensile strength of concrete cylinders with a 7% TiO_2 substitution reveals a higher value than normal concrete.
- Similarly, when flexural strength is compared to regular concrete, the beam with 7% TiO_2 substitution has a better value.
- As the value of the concrete cylinder and beam grows with a lesser percentage of TiO_2 replacement, the use of a smaller proportion of TiO_2 produces useful results.

VI. Recommendation

From further study we observe that the following parameters such as shrinkage, workability, durability, Air content, and heat resistance property of titanium dioxide should be studied. Because if the cracks develop on the surface of the concrete, it decreases the strength of concrete. And also, researcher need to be focused on producing a functional geopolymer concrete with self-cleaning behaviour.

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