SSRG International Journal of Civil Engineering
ISSN: 2348 – 8352 /doi:10.14445/23488352/IJCE-V7I12P103

Volume 7 Issue 12, 9-12, December 2020

An Experimental Study On Tio$_2$ Based Self Cleansing Concrete By Partial Replacement of Sand By Waste Glass

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Received Date: 15 November 2020
Revised Date: 25 December 2020
Accepted Date: 31 December 2020

Abstract - *The world is facing the problem of controlling air pollution from vehicle emissions, especially in growing urban areas. This study innovatively investigates applying the photocatalytic effect of titanium dioxide (TiO_2) onto the concrete pavement to remove one of the major air pollutants, carbon monoxide. Photocatalytic compounds have the potential to remove harmful air pollutants from urban areas. There are three methods for applying TiO_2 –cement-based thin coating, water-based titanium dioxide solution, and a sprinkling of TiO_2 – to the fresh concrete surface before hardening. We have adopted a cement-based titanium dioxide solution method. The samples' environmental efficiency to remove carbon monoxide from the atmosphere was measured using a newly developed laboratory setup. This study involves using titanium dioxide as a photocatalyst in the concrete mix, which develops into a self-cleaning concrete, reducing the air pollution in the surrounding. This paper recommends the effective use of ceramic waste as a 10% replacement of fine aggregate. An experimental investigation was carried out on concrete containing Tio$_2$ in the range of 12% and 28% by the weight of M_{25} grade of concrete. The concrete was produced, tested in compressive strength test and emission test, and conventional concrete.*

Keywords: *Ceramic waste, Titanium dioxide, self-cleansing concrete, photocatalyst.*

I. INTRODUCTION

Air pollution caused by road traffic and industry is one of the major problems in metropolitan and urban areas. Despite intensifying emission control requirements and the increased installation of emission reduction systems, air pollution, and pollution by carbon monoxide will remain a serious issue shortly. The by far largest emissions are generated by local traffic and industrial flue gases. There are many attempts to reduce emissions, from the encouragement of carpooling and public transportation to redesigning the vehicles themselves. However, there are still emissions polluting the air to a significant degree.

The photocatalyst, titanium dioxide (TiO_2), is a naturally occurring compound that can decompose gaseous pollutants in the presence of sunlight. Applying TiO_2 to pavement can remove emission pollutants right next to the source, near the vehicles that drive on the pavement itself. However, surface coatings to traditional pavements may lose their effectiveness due to surface wear. Hence water-based titanium dioxide solution method is adopted.

When light and heat strikes the concrete's surface, catalysts (usually titanium oxides) use that energy to break down the dirt into molecules like oxygen and water. Gases float away while liquids or solids are left on the surface to be washed away by rain.

With this innovative idea, this paper aims to identify the effectiveness of applying titanium dioxide (TiO_2) to the concrete pavement, thus producing a greener urban road environment.

OBJECTIVE

Evaluate the effectiveness of titanium dioxide (TiO2) treated concrete by adopting a water-based titanium dioxide solution method. A laboratory environmental setup was used to evaluate the carbon monoxide removal efficiency due to the photocatalytic effect of the TiO_2.

SCOPE

By developing self-cleaning concrete, the concrete keeps its color far longer than traditional building materials, so it doesn't need to be replaced so often. It can also reduce general air pollution.

USES OF SELF CLEANSING CONCRETE:

- Self-cleansing concrete can be used both in pavements and building structures.
- In building structures, self-cleansing concrete can improve indoor air quality by breathing a safe Environment and keeping the building brighter.
- In concrete pavements, it appears to be useful for reducing harmful airborne pollutants. Compared to conventional concrete.

BACKGROUND OF PHOTOCATALYST:

The technology was invented pretty much by accident by Luigi Cassar, an Italian chemist at cement manufacturer Italcementi. He was trying to create a construction material that would keep a bright white color even in polluted conditions and hit upon a method called "photocatalysis," which uses the sun's energy to zap away dirt.

Titanium dioxide is a semiconductor, which has three crystal arrangements: anatase, rutile, and brookite. Of the three, research has shown that titanium dioxide in the anatase phase exhibits the highest photoactivity in environmental purification.

In the sunlight, TiO_2 is activated by ultraviolet (UV-A) radiation to oxidize air pollutants such as carbon monoxide into inorganic compounds. In a photocatalytic reaction with TiO_2, no chemical reactants are used. The TiO_2 does not get consumed in the reaction, so it can theoretically be used indefinitely.

Photocatalysts activated by UV lights will decompose organic materials like dirt, biological organisms, airborne pollutants, and chemicals that cause odors.

Photocatalytic concrete is starting to be used more in architectural and civil engineering projects in Europe and Asia as a self-cleaning material.

Some benefits of photocatalytic concrete are that it decomposes chemicals that contribute to soiling and air pollution. It keeps the concrete cleaner, reflects much of the sun's heat, and reduces heat gain because of its white color. TiO_2 is recently found to be an excellent photocatalyst to be used in pavement engineering for reducing vehicle emission pollutants.

Pollutants from vehicle exhaust adsorb to the pavement. The TiO_2 coating on the pavement surface activates with the ultraviolet sunlight to break down the pollutants. The final products are then desorbed from the pavement.

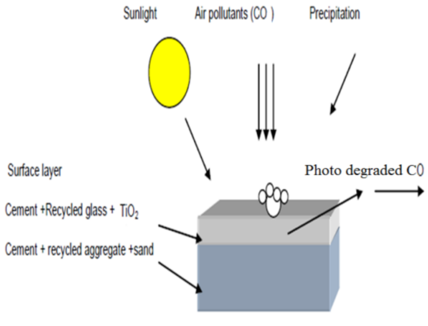


Fig 1. PHOTOCATALYTIC REACTION

II. PREPARATION OF MATERIALS

This study's cement material is an Ordinary Portland Cement (OPC) commercially available in the market. The recycled aggregate (RA) is also used in this study. It is a crushed glass waste sourced from a temporary recycling facility. In the plant, the glass waste underwent mechanized sorting; only the smaller fine aggregate proportion was used for making the surface layer of the blocks in this study. This crushed glass will increase the reacting space of the Titanium Dioxide in the concrete under UV-A radiation. The maximum size of the fine recycled aggregate used is 2.36 mm. The sand that was used is fine natural river sand commercially available in the market. The chemical material photocatalyst used is Titanium dioxide (TiO_2). The best source of titanium dioxide is Anatase crystalline form, which is commercially available, which was used due to its high purity and accurate specifications. It is used in the industry and research community.

FOR PHOTOCATALYST CONCRETE

TiO_2 catalyst 28 % of cement

The ratios of cement, TiO_2, sand, and aggregate is as follows

Cement : TiO_2 : sand : aggregate 1: 0.28: 1.083 : 2.03

For 8 cubes

Cement = 16.12 kg

TiO_2 = 4.536 kg

Sand = 16.12 kg

Crushed Glass = 1.612 kg

Coarse aggregate = 24.3 kg

TiO_2 catalyst 35 % of cement

The ratios of cement, TiO_2, sand, and aggregate is as follows

Cement : TiO_2 : sand : aggregate 1: 0.35 : 1.083 : 2.03

For 8 cubes

Cement = 16.12 kg

TiO_2 = 5.66 kg

Sand = 16.12 kg

Crushed glass = 1.612 kg

Coarse aggregate = 24.3 kg

Fig 2.RECYCLED FINE AGGREGATE

III. MIX PROPORTIONS

Mixes were prepared with cement, sand, Recycled glass aggregates, TiO_2, and water. This study focuses on the efficiency of titanium dioxide used in the concrete to convert harmful carbon monoxide into harmless carbon monoxide. To achieve a better percentage of Carbon monoxide removal efficiency, two proportions of mixes were prepared. Mixes with varying quantities of titanium dioxide, such as 28% of cement and 35% cement, were prepared and used.

Fig 4CONCRETE CASTING AND CURING

IV. RESULTS & DISCUSSION

COMPRESSIVE STRENGTH OF CONCRETE
Compressive strength is the capacity of a material or structure to withstand loads tending to reduce the size instead of tensile strength, which withstands loads tending elongate. In other words, compressive strength resists compression (being pushed together), whereas tensile strength resists tension (being pulled apart). Compressive strength can be measured by plotting applied force against deformation in a testing machine, such as a machine. The investigation is carried out to study the compressive strength of concrete. The compressive strength of conventional and self-cleansing concrete at 14 days and 28 days for M25 grade concrete is tabulated in Table. In the M_{25} grade of concrete, the compressive strength at 14 days and 28 days are given in the Table. It is observed that the compressive strength of self-cleansing concrete with 28% and 35% of Titanium dioxide is similar to that of conventional concrete.

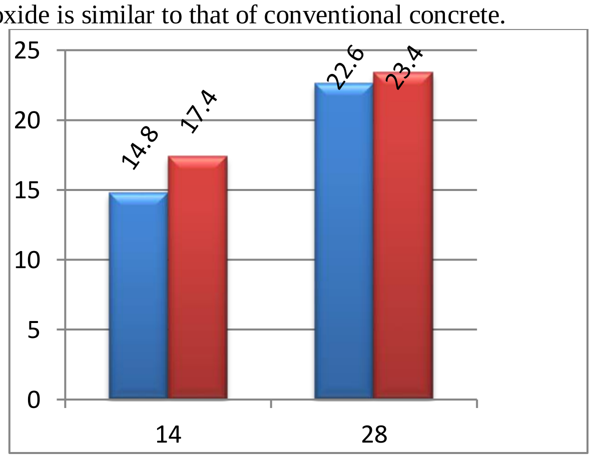
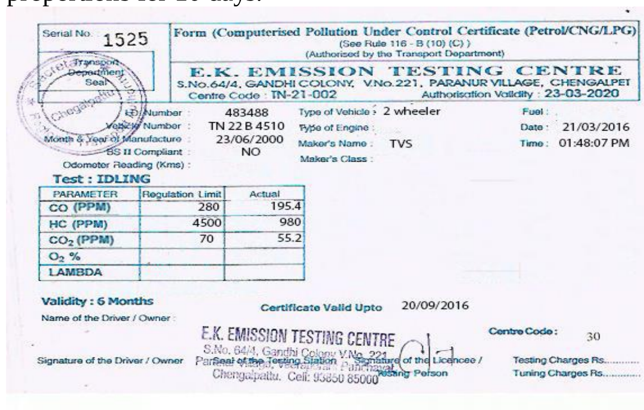


Fig 5 Comparison of Compressive Strength between Conventional and Self-cleansing Concrete with 28% of Titanium dioxide with Age

CO - ANALYSIS

The investigation is carried out to study the variation in Carbon monoxide reduction using Conventional for 10 days and Self-cleansing concrete of various proportions for 10 days.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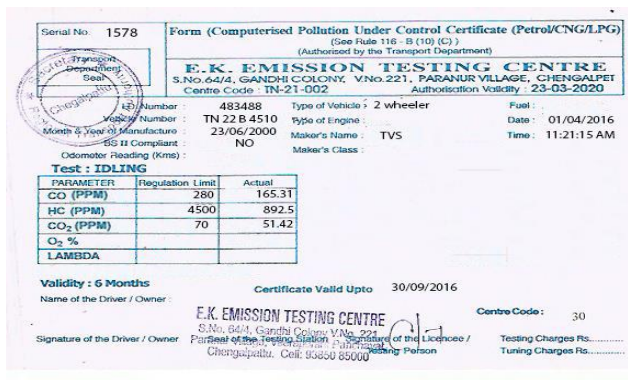
(See Rule 116 - B (10) (C))
(Authorised by the Transport Department)
E.K. EMISSION TESTING CENTRE
S.No.64/4, GANDHI COLONY, V.No.221, PARANUR VILLAGE, CHENGALPET
Centre Code : TN-21-002 Authorisation Validity : 23-03-2020
ID Number : 483488 Type of Vehicle : 2 wheeler Fuel :
Vehicle Number : TN 22 B 4510 Type of Engine : Date : 21/03/2016
Month & Year of Manufacture : 23/06/2000 Maker's Name : TVS Time : 01:48:07 PM
BS II Compliant : NO Maker's Class :
Odometer Reading (Kms) :
Test : IDLING

PARAMETER	Regulation Limit	Actual
CO (PPM)	280	195.4
HC (PPM)	4500	980
CO_2 (PPM)	70	55.2
O_2 %		
LAMBDA		

Validity : 6 Months
Certificate Valid Upto 20/09/2016
Name of the Driver / Owner
E.K. EMISSION TESTING CENTRE
Centre Code : 30
Signature of the Driver / Owner Seal of the Testing Station Signature of the Licencee / Testing Person
Testing Charges Rs.........
Tuning Charges Rs.........

Fig 6 EMISSION TEST VALUE FOR CONVENTIONAL CONCRETE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(Authorised by the Transport Department)
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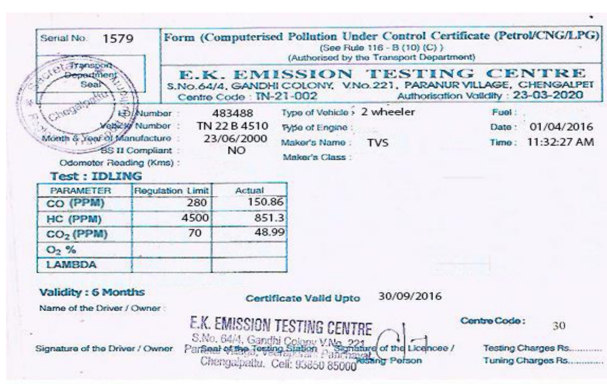
S.No.64/4, GANDHI COLONY, V.No.221, PARANUR VILLAGE, CHENGALPET
Centre Code : TN-21-002 Authorisation Validity : 23-03-2020
ID Number : 483488 Type of Vehicle : 2 wheeler Fuel :
Vehicle Number : TN 22 B 4510 Type of Engine : Date : 01/04/2016
Month & Year of Manufacture : 23/06/2000 Maker's Name : TVS Time : 11:21:15 AM
BS II Compliant : NO Maker's Class :
Odometer Reading (Kms) :
Test : IDLING

PARAMETER	Regulation Limit	Actual
CO (PPM)	280	165.31
HC (PPM)	4500	892.5
CO_2 (PPM)	70	51.42
O_2 %		
LAMBDA		

Validity : 6 Months
Certificate Valid Upto 30/09/2016
Name of the Driver / Owner
E.K. EMISSION TESTING CENTRE
Centre Code : 30
Signature of the Driver / Owner Seal of the Testing Station Signature of the Licencee / Testing Person
Testing Charges Rs.........
Tuning Charges Rs.........

Fig 7 EMISSION TEST VALUE FOR SELF CLEANSING CONCRETE AT 28% OF TITANIUM DIOXIDE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Form (Computerised Pollution Under Control Certificate (Petrol/CNG/LPG)
(See Rule 116 - B (10) (C))
(Authorised by the Transport Department)
E.K. EMISSION TESTING CENTRE
S.No.64/4, GANDHI COLONY, V.No.221, PARANUR VILLAGE, CHENGALPET
Centre Code : TN-21-002 Authorisation Validity : 23-03-2020
ID Number : 483488 Type of Vehicle : 2 wheeler Fuel :
Vehicle Number : TN 22 B 4510 Type of Engine : Date : 01/04/2016
Month & Year of Manufacture : 23/06/2000 Maker's Name : TVS Time : 11:32:27 AM
BS II Compliant : NO Maker's Class :
Odometer Reading (Kms) :
Test : IDLING

PARAMETER	Regulation Limit	Actual
CO (PPM)	280	150.86
HC (PPM)	4500	851.3
CO_2 (PPM)	70	48.99
O_2 %		
LAMBDA		

Validity : 6 Months
Certificate Valid Upto 30/09/2016
Name of the Driver / Owner
E.K. EMISSION TESTING CENTRE
Centre Code : 30
Signature of the Driver / Owner Seal of the Testing Station Signature of the Licencee / Testing Person
Testing Charges Rs.........
Tuning Charges Rs.........

Fig 8 EMISSION TEST VALUE FOR SELF CLEANSING CONCRETE AT 35% OF TITANIUM DIOXIDE

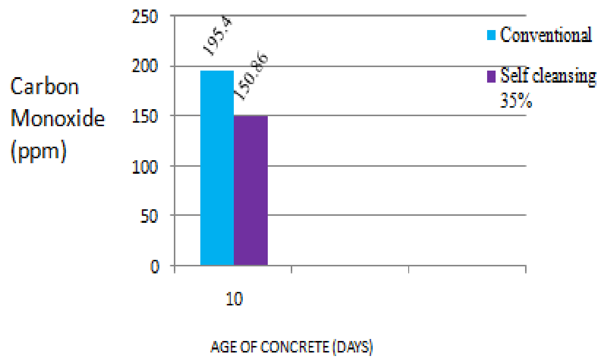

Fig 9 COMPARISON OF CONVENTIONAL CONCRETE AND SELF CLEANSING CONCRETE AT 35% TIO_2

V. CONCLUSION

The developed self-cleansing concrete is economical and can control the surrounding air quality with titanium dioxide. The expected efficiency of self-cleansing concrete is 35%, but we have achieved only 22.4%. Yet it can be used for the pavement to reduce the harmful effects of pollution and also it keeps the concrete white and clean than the conventional concrete. Thus the maintenance is not required for this concrete. This makes the surroundings free from pollution and gives us good and clean air to breathe.

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