Review Paper on Photocatalytic Concrete Using Titanium Di-Oxide

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Abstract- *Concrete is the most extensively used construction materials for building technology. However, cement production releases high amounts of carbon dioxide (CO2) to the atmosphere that leads to increasing the worldwide or global warming. Thus, an another, environmental friendly construction material such as photocatalyst concrete has been developed. Photocatalytic concrete applies greener alternative binder, which is an modern-day construction material that replaces the Conventional cement. This technology presented nano-particles such as nanoclay into the cement paste in order to improve their mechanical properties. The concrete materials also have been developed to be performed as self-cleaning construction materials. The self-cleaning properties of the concrete are induced with the help of photocatalytic materials such as titanium Di-oxide(TiO2). Self-cleaning concrete that contains those photocatalytics will be energized by ultraviolet (UV) radiation and quickens the decomposition of organic particulates. Thus, the spotlessness of the building surfaces can be maintained and the air surrounding air pollution can be reduced. This paper briefly reviews about self-cleaning concrete.*

Keywords- Photocatalyst, Titania, Ultravoilet Radiation, Nano Particles, Nano Clay, Photocatalytic.

I. INTRODUCTION

1.1General Introduction

A building material eradicate pollutants from the air as it keeps its surface clean. This latest amazing concrete that not only keeps itself clean but also eliminates pollutants from the air is called Self Cleaning Concrete. The key to such properties are photo catalytic components that use the energy from ultraviolet rays to oxidize most organic and some inorganic compounds [6]. Air pollutants that would normally result in discoloration of open surfaces are eliminated from the atmosphere by the components, and their residues are washed off by rainwater [6]. So, this latest cement can be used to make concrete and plaster products that save on maintenance costs while they ensure a fresher environment. Interior air in buildings can be more polluted than outdoor air because there are numerous sources of pollution in some large cities.

For decades, scientists have recognized dual exclusive effects of titanium dioxide, a usual compound that is used in products as diverse as quick-setting concrete, tile grout and even suntan lotion. When expose to the sunlight, titanium dioxide (TiO2) acts as a catalyst to break down the organic matter, while also creating a super hydrophilic surface. The useful function of TiO2, which can both serve as photocatalytic materials and structural materials, has facilitated its use in exterior construction materials and interior furnishing materials, such as cement mortar, exterior tiles, PVC fabric, glass and paving blocks.

As such the use of the unique additive promotes self-cleaning of huge concrete structure and at the same time promotes reactions that help in cleansing the environment as well. The properties of photocatalyst are including photocatalytic water purifications and air purifications, self-cleaning property and photocatalytic anti-bacterial effect. Its function is limited because of chemical engineering restrictions such as support of photocatalysts or separation of the photocatalysts from the effluent.

Self cleaning or photo catalytic concrete, by the name itself it shows its affordability. The name that it looks like revolutionary ideas and some of us may think that it is impossible. But then again it is practical now, many foreign countries are stick to the concrete for its incredible beneficial results. Concrete construction is a expansive field we can innovate into new creation. By using this concrete cleaning technology, we can create a beautiful atmosphere and improve the anti-aging of concrete [11]. However, this type of concrete produces the indoor air purification so we can reduce the health issues. Breathing problems can be reduced slowly. Protecting concrete not ever creates an aware towards users we can take step to achieve this self- purifying/ cleaning technology to purify the concrete using photo catalyst. Photo catalyst is best filters towards the concrete it creates friendly reactivity over the concrete. The response over the cement is neutral it can be washed away by spraying water it will not create any harm to cement and not affect the cement binding properties. Clean buildings provide astonishing environmental benefit is the potential for cleaner air.

Photocatalytic materials represent a technology that could help to mitigate ultraviolet rays and air pollution [5]. These materials use sunlight or additional ultraviolet light sources to react with pollutant molecules and convert them to less damaging substances that can be washed away. In this way, photocatalytic materials reduce NOx, SOx, VOCs, etc., and also serve as self-cleaning materials. Self-cleaning buildings and pollution-reducing highways may sound like futuristic ideas, but they are the truths of some of today's concrete .

Self-cleaning concrete, also known as smog-eating concrete, is one of modern inventions in the field of civil and environmental engineering. Technology based on particles of titanium dioxide, TiO2, is what makes this concrete unique. The technology can be functional by incorporating TiO2 directly into concrete or by incorporating TiO2 into photocatalytic coatings for concrete samples. It can be used in each varieties of concrete, and the lone difference is that it is capable of breaking down smog or other pollution that has attached itself to the concrete, in a procedure known as photocatalysis. As sunlight hits the surface, most organic and some inorganic pollutants are neutralized [5]. They would otherwise lead to faded concrete surfaces. Rain washes away the pollution from the concrete surface so the buildings stay dirt free, and even more essential environmental benefit is the cleaner air.

1.2 Necessity

Photocatalytic concrete has the ability to realize air de pollution, self-cleaning, plus self-disinfecting. It is fabricated by totalling photocatalyst into traditional concrete, and the best suitable photocatalyst to fabricate photocatalytic concrete is Titanium Di-oxide (TiO_2). The photocatalytic reaction can happen under the light when energy is higher than the photocatalyst band gap. The formed highly oxidizing hydroxyl radicals can react with contaminants and create carbon dioxide, water, or other harmless substances. The decomposed pollutants can be taken away by wind or rain to attain the purpose of air depollution and self-cleaning. The photocatalytic concrete has immense capacity in the field of degradation of pollutants, deodorization, sterilization, and energy conservation.

1.3 Application

The use of photocatalysts in concrete technology is by now a well-founded concept. However, despite the big opportunities for air quality improvements to be derived from the considerable concrete surfaces exposed to the atmosphere, mainly in cities where air quality is greatly affected by vehicle exhaust plus industrial area emissions, Photocatalytic concretes are still not in main stream function. With current levels of NOx pollution considerably exceeding EU legislative rules in urban centres throughout the industrialised globe, it is important to consider what the issues are. The likely obstructions to more widespread implementation are likely to contain cost effectiveness, which needs to be related to photocatalyst impact, but the challenges in measuring impact on air quality directly are complex. This paper seek out to place photocatalytic efficiencies into context, equating performances of the traditional photocatalyst dispersion in surface mortar coatings with that of photocatalysts supported on open or exposed surface aggregates. The nature and influence of catalyst binding to the aggregate is also discussed in this paper.

1.4Photocatalytic mechanism

TiO2 is the prime photocatalytic ingredient and studies have shown that TiO2 incorporated into building materials can keep surfaces clean (surface-cleaning) and significantly decrease smog-forming air pollutants. As soon as a TiO2 surface is open to UV light, two categories of photochemical reactions occur: photo-induced redox reactions of the absorbed pollutants and photo-induced hydrophilic conversion. When TiO2 absorbs UV-A radiation from sunraysor an illuminated light source such as a fluorescent lamp, it will generate pairs of electrons and holes. In the presence of light, the electrons become excited and generate energy. The photo-produced holes represent saved energy. The excess energy produces the negative-electron (e-) and positive-hole (h+) pair . With water and Ultraviolent light present, the electron hole reacts with the OH-group from adsorbed water, generating hydroxyl radicals and charged species at the surface of the catalyst. During this encounter, an OH-group fails an electron and extremely reactive hydroxyl radicals can form. Such radicals react with airborne pollutant molecules that are adsorbed by the particle's surface. These reaction products remains on the surface up until they are fully oxidized. In addition, the decreasing power of the electrons can induce the reduction of molecular oxygen (O2) to superoxide (O2-). This is as efficient as the holes and hydroxyl radicals in the chain reactions for breaking down organic compounds. The photocatalytic conversion of NO, which leads to the formation of weak nitric acid HNO3. Most cement formulations are alkaline, which neutralizes HNO3. As shown in Equations 1.5.1 to 1.5.3, acid reacts with calcium carbonate, locking of the NOx gases up in calcium nitrate and releasing CO2 and water.

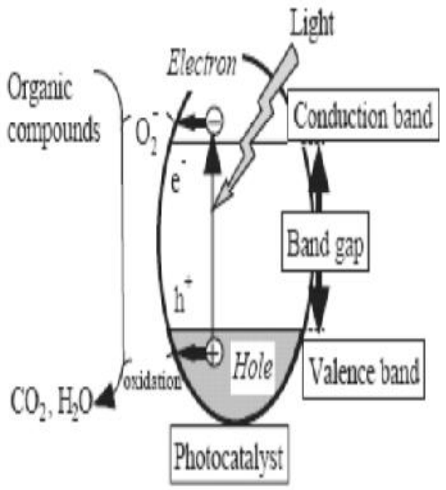


Fig: 1 Photocatalytic mechanism

$$NO + 1/2O_2 \rightarrow NO_2. \qquad (1.5.1)$$
$$2NO_2 + 1/2\ O_2 + H_2O \rightarrow 2HNO_3\ (1.5.2)$$
$$HNO_3 + CaCO_3 \leftrightarrow (NO_3)_2 + H_2O + CO_2 (1.5.3)$$

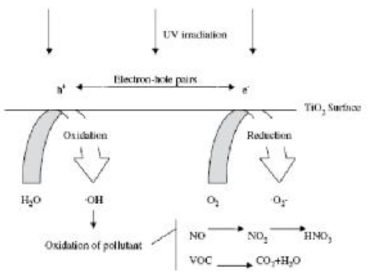


Fig: 2 Photocatalytic conversion of NOx to HNO_3

II. LITERATURE SURVEY

2.1 Literature Review

Preparation of titanium dioxide nano particle modified Photocatalytic self-cleaning concrete.
WeiguoShen[a, b, c, *] , Chuang Zhang [c] , Qiu Li [b] , Wensheng Zhang [d] , Liu Cao [c] , Jiayuan Ye [d]

In this chapter The photo-catalyst concrete was widely studied but due to the rough surface of the concrete, no real self-cleaning concrete had been prepared ever before this paper.In This work they prepared a new type of Photocatalytic Ultra-Smooth Concrete. This concrete looks like a mirror, when the analyzed range is 1.0 x 1.0 mm2 , the Z rang of this area is around 45e100 nm, the arithmetic mean roughness of the choice area is 3.5e11 nm. And the concrete can degradation the MB blue efficiently, as an ultra smooth photo-catalytic concrete, it is a actually self-cleaning concrete which is promising finishing material for buildings, the nano-TiO2 particles only was used on the surface of this product, so the cost of this product is cost-effective.

Behaviour of Self Cleaning Concrete by using various Photocatalysts.
ANJU RAJ[1] Student, M Tech Structural Engineering and Construction Management, M A College of Engineering, Kothamangalam, Ernakulam, India

In this chapter Titanium dioxide (TiO2) or zinc oxide (ZnO) are included to concrete by 0, 0.5, 1, and 1.5% of cement by weight. The compressive strength of concrete cubes cured for 28 days were taken. Durability test of self cleaning concrete was tested by using magnesium sulphate (MgSO4)& sodium chloride (NaCl) mixture. Self cleaning property of the self cleaning concrete is researched by using RhB (Rhodamine dye) discolouration under Ultraviolent light, it is a basic test for self-cleaning cementitious materials.

Study on the Properties of Self Cleaning Concrete Using Titanium Dioxide
Dr. S. U. Kannan[1], Jebin Raj[2], Jerom Antony[2], Manoj[2], Mujahid[2],

In this paper a brief study has been carried out on the properties of self cleaning concrete using Titanium dioxide. The decolourization also oxidation effect are studied using Rhoda mine dye and nitrogen dioxide correspondingly. After Testing the concrete in which cement is partially replaced by 3% of titanium dioxide shows steady increase in compressive strength. And they also found out Compressive strength of concrete sample with 3%, 4% and 5% of titanium dioxide after 28 days curing is greater than the target mean strength.

Titanium dioxide as photocatalyses to create self cleaning concrete and improve indoor air quality.
Arafa Awadalla, Muhammad Fauzi Mohd Zain, Abdul Amir H. Kadhum and Zeinab Abdalla

This paper gives the results of a study on the efficiency of contributing air cleaning agents such as Titanium dioxide (TiO2) into the method of producing concrete composite panels, using local waste materials for solving the difficulty of carbon dioxide (CO2) in indoor air buildings. Factors which would have an effect on the functioning of the panel were studied, including the porosity of panel, dissimilar types of waste materials and types percentage of TiO2 used within the mix design. The degradation procedure under laboratory conditions was studied using chemilumine scence analysis method for calculating the performance of photocatalytic active concrete products. The results show that the photo degradation of CO2 is linked to the porosity of the sample; when the porosity of sample was increased, the CO2 had deletion ability.

Self-Cleaning Concrete – A Construction Material For Building Cleaner World.
Adnan Mujkanović[1] ,Dženana Bečirhodžić[1] , Nevzet Merdić[21] University of Zenica, Faculty of Metallurgy and Materials Science Travnićkacesta[1], Zenica[2] Cement plant "Kakanj", Kakanj Bosnia and Herzegovina

This paper gives a review on self-cleaning concrete, the key principle of self-cleaning concrete and its now a days uses. Self-cleaning concrete is one of newest innovations in the field of civil and environmental engineering. Application of TiO2 photocatalysis is what makes this concrete different. The technology can be applied by including TiO2 directly into concrete or by including TiO2 into photocatalytic coatings for concrete specimens. In this procedure, the synergy of sun-light, atmospheric oxygen and water allows to attain self-cleaning surface. The photocatalys is starts with activation of the photoactive TiO2 at the surface of the material under the effect of ultraviolet light. In the next step of procedure the pollutants are oxidized due to the presence of the photocatalyst and precipitated on the surface of the material. At the end, they are removed from the surface by the rain fall or cleaning/washing with water. In this way constructions stay cleaner and maintenance costs are decreased.

Experimental Study On Self Cleaning Concrete By Replacing Cement By Titanium Dioxide
Rajamuniasamy*, Mercy, Praveen***, Devan****, Shindo*****

This paper briefly reviews about self-cleaning concrete. They discovered that The concrete in which cement is partly replaced by 3% of titanium dioxide shows gradual increase in compressive strength, Compressive strength of concrete sample with 3%, 4% and 5% of titanium dioxide after 28 days curing is greater than the target mean strength, The oxidation of nitrogen dioxide gas is high when titanium dioxide content is more, The decolourization and oxidation process is primarily depends on climate of the environment.

An environmental friendly solution for air purification and self-cleaning effect: the application of TIO2 as photocatalyst in concrete
Anne Beeldens, Researcher, Belgian Road Research Centre

This paper gives an overview of the principle of photocatalysis and the use in combination with cement, as well as the results of the laboratory study, especially towards air purifying action. The implementation of this type of material in an urban and interurban area is examined. A large scale realization with concrete pavement blocks is completed on the main roads (Leien) in the centre of Antwerp.

This paper spot lights on the application of TiO2 as Photocatalytic material in concrete pavement blocks. The addition of Titanium Di-oxide in building materials adds an extra property to the roads. Purification of the air, which is in contact with the surface, is obtained when the surface is open to UV-light (present in light of day). The measurements in the research laboratory on photocatalytic pavement blocks gave good results towards air purification, calculated as NOx reduction. The best findings were obtained by high temperature (> 25°C), low relative humidity, high light intensities and long contact times. This condition is obtained on hot sunny days, without any wind, when the risk on smog formation due to the high rate of pollution is the biggest.

Self-cleaning geopolymer concrete - A review
S N Zailan[1] , N Mahmed[1] , M M A Abdullah[1, 2] , A V Sandhu [3]

This paper aims to give an summary on self-cleaning concrete (SCC). With these growth of technology, air pollutions can be reduced because self-cleaning contribute to the removal of VOC's that present in indoor and outdoor atmosphere. Nowadays, air pollution is a dangerous problem in urban environment that can have an effect on human health. Thus, self-cleaning concrete is an effective alternative to give cleaner environment and maintain building appearance. Through the growth of cementitious materials, UV radiation from the sun may represent one of the solutions to the pollution problems. In conclusion, self-cleaning can be used in various application, specifically cementitious materials which contribute to sustainability and towards green environment. Additional research need to be focused on producing a functional geopolymer concrete with self-cleaning behaviour.

Study on Self-Cleaning Concrete Using Nano-liquid TiO_2
T.Vignesh[1] , A.Sumathi[2] , K. Saravana Raja Mohan[3]

In these paper, The present work discovers to study the compressive strength of concrete and self-cleaning properties of the concrete by the using nanoliquid Titanium Di-oxide (TiO2) on fresh concrete with different dosages (0, 2.5, 5.0, 7.5 ml) and single, double, as well as triple layer coating of nano-liquid Tio2 on the hardened concrete surfaces. Cement was partially replaced with Fly ash. In this study cement was replaced with 30% fly ash and to inspect self cleaning properties of concrete by using Rhodamine-B dye (RhB) discoloration test under Sunlight/Ultraviolent light visual open eye observation. Concrete samples with Photocatalytic nano-liquid Tio2 was combined with fresh concrete (NF) showed enhanced compression strength by increasing the dosages when equated to the nano-liquid Tio2 was coated on the surface of the hardened concrete (NH). Self cleaning capability of NH of samples showed better results in cleaning ability than NF samples.

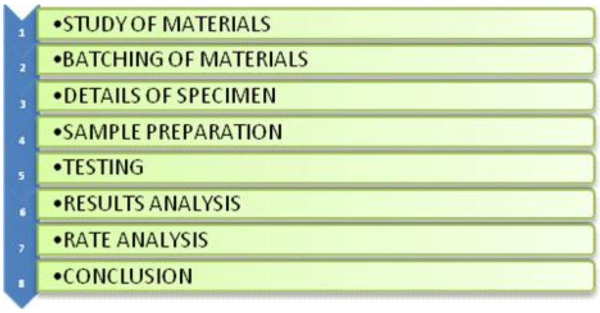
A Review on Pollution Eating and Self Cleaning Properties of Cementitious Materials
AbhijeetShukla[1] , Rao Faraz Waris[2] , Mohd. Arhab[1] , Syed Sajid Husain[1]

The main focus of this paper is to describe the mechanisms included and to understand the merits and demerits of using this cementitious material in a improved way and also it targets at finding out different ways in which it can contribute more to this modern environmental friendly world. Paper contains Case studies of Cermak Road in Chicago (USA) and Street Jean Bleuzen, Vanves, France and Torre de Especialidades, Mexico City.

3.1Objectives

a) To study environmental sustainability.
b) To study the use of TiO2 as eco-friendly material.
c) To study the methods of reducing air pollution.
d) To reduce patch formations.
e) To keep concrete young.

3.2Research Methodology



3.2.1Study of Materials

3.2.1.1Ordinary Portland cement

Ordinary portl and cement will be used for the current study (grade 53). The tests were performed according to Indian Standard recommendations. The physical properties of cement are given in Table 1**.**

Table 1 Physical properties of Cement

	Properties	Value
1	Specific gravity	3.15
2	Standard consistency (%)	31
3	Initial setting time (in minutes)	44
4	Final setting time (in minutes)	384
5	Fineness	7%

3.2.1.2 Fine Aggregate

Natural fine aggregate will be used for the experimental study was produceds and. The physical properties of fine aggregate are provided in Table2.

Table 2 Properties of Fine Aggregate

Sr No	Properties	Test Results
1	Water absorption (%)	0.6
2	Specific gravity	2.59
3	Bulk density(kg/l)	1.31
4	Fineness modulus	3.476
5	Uniformity coefficient (D60/D10)	5.677
6	Effective size (D10)	0.155
7	Grading zone	Zone II

3.2.1.3Coarse Aggregate

Crushed granite angular aggregate from a local source, with a maximum size of 20mm, will be used for the currentstudy. The physical properties of natural coarse aggregate are providedin Table 3.

Table 3 Physical properties of natural Coarse Aggregate

SR. No	Properties	Test Results
1	Water absorption (%)	1.3
2	Specific gravity	2.69
3	Bulk density	1.5g/cc
4	Fineness modulus	4.309
5	Uniformity coefficient (D60/D10)	1.29
6	Effective size (D10)	15.523

3.2.1.4 Titanium dioxide (TiO_2)

Table 4 Properties of TiO_2

Average particle size (nm)	35
Specific gravity	1.34-1.4
Density (g/cm3)	0.25
Purity (%)	99%
Colour	White

3.2.2 Batching of Materials:

Volume batching is not appropriate method for proportioning the material because of inconveniency it offers to measure granular material in terms of volume. Volume of moist sand in loose conditions weighs far much less than the equal volume of dry compacted sand. The amount of solid granular material in cubic meter is indefinite quantities for the reason of this for quality concrete materials have to measure by weigh only.

3.2.3 Details of specimens:

The cube specimens of 150 x 150 x 150 mm were cast for control mix (CM) as per mix design. While casting cubes, to study the properties of concrete with partial replacement of cement by titanium dioxide. The compressive strength of cubes after replacing cement by 3%, 4% and 5% is check for after 28 days for test specimens, 53 grade Portland cement, manufactured sand and coarse aggregate, titanium dioxide are being used. The maximum size of coarse aggregate was restrained to 20mm. The concrete mix proportion water cement ratio of 0.4 were used.

The concrete cube (150 x 150 x 150 mm) for conventional as well as other mixes were casted. Every layer was compacted with 25 no. of blows using 16mm diameter rod.

3.2.4 Testing:

a) Compressive strength test:

Compressive test is the most usualtest conducted on hardened concrete, partly because it is an easy test to perform the partly because of the desirable characteristics properties of concrete are qualitively related to its compressive test. The tests are carried on UTM or CTM and load and compressive load is observed for the ultimate failure.

In this project the cement will be partly replaced by titanium oxide in 3%, 4% and 5% by weight of cement. The specimens will be casted and cured. The compressive strength of concrete will be determined as per Indian Standard (IS) specification.

Fig: 3 Digital Compression Testing Machine

b) Rhodamine B Dye Decolourization Test:

In this test the concrete having Titanium Di-oxide (TiO2) photocatalyst have been evaluated based on decolourization under sunlight, it is a basic test for self cleaning cementitious material. Experimental data are discussed in relation to dye decolourization of 3%, 4% and 5% of TiO2 replaced concrete under sunlight.

On exterior surface of the casted concrete cubes 1ml of rhodamine dye is dropped on each cube sample and placed under direct sunlight and results will be observed.

The decolourization of rhodamine dye happens on the exterior surface of the cubes after some hours.

3.3 Possible Outcome

a) To providing the “self cleaning” ability of concrete surfaces, by retaining their light colour for longer, along with the property to remove airborne toxins, particularly nitrogen oxides.
b) A construction material eliminate pollutants from the air as it keeps its surface clean.
c) The key functions of Titanium Di-oxide (TiO2) based Photocatalytic building materials contains environmental pollution remediation, self cleaning and self-disinfecting.
d) To accomplish the sustainability self cleaning concrete used in building material the way for the modern civil engineers.
e) In this concrete the photocatalysts will be enhanced by ultraviolet(UV) radiation and it decomposes the organic particles present on the surface of the concrete.

3.4 Future scope

a) To conduct a detailed literature review.
b) To conduct a laboratory experimental program to characterize the mechanical, transport and durability properties of photocatalytic concrete in comparison with conventional concrete.
c) To examine high pollution regions in Ontario (including Toronto) and assess the interplay between pollutant concentrations.
d) To detectregions where photocatalytic concrete infrastructure has the capacity to be most effective based on the experimental outcomes.
e) To reveal the influence of environmental conditions, particularly temperature, on the photocatalytic pollution degradation mechanism in order to develop a correlation between photocatalytic effectiveness and seasonal climate.

IV. ACKNOWLEDGMENT

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