

Experimental Study of Modified Self Cleaning Concrete Using Silicon dioxide

Nafzin V N¹, Salman P A¹, Sunshy V G¹, Zaara James¹, Husaiba N M²

B.Tech Student, Department of Civil Engineering, KMEA Engineering College, Ernakulam, Kerala, India¹

Assistant Professor, Department of Civil Engineering, KMEA Engineering College, Ernakulam, Kerala, India²

ABSTRACT: Self Cleaning Concrete is prepared by adding photocatalytic materials into concrete mixture. And the most important property of this concrete is its self cleansing ability. Titanium dioxide, silicon dioxide, tin dioxide, zinc oxide, zirconium dioxide are the different photocatalytic materials. Of these photocatalytic materials titanium dioxide (TiO₂) exhibits major photocatalytic properties and helps to reduce major atmospheric pollutants such as sulphur oxide (SO_x), nitric oxide (NO_x), volatile organic compounds (VOC_s) etc. And thus self cleaning concrete which is a depolluting concrete made by adding titanium dioxide into concrete mixture. Silicon dioxide (SiO₂) is another photocatalytic material which exhibits properties similar to that of titanium dioxide. This paper, presents the experimental study of modified self cleaning concrete prepared by adding silicon dioxide. The photocatalytic materials absorb ultraviolet radiations from the sun then, hydroxyl radicals and superoxide anions are created and they have the ability to react with pollutant molecules such as SO_x, NO_x, VOC_s and thus converting to less harmful compounds. Self cleaning concrete is an alternative to provide a cleaner and eco-friendly environment and which contributes to sustainability. Self cleaning concrete is also known as photocatalytic concrete.

KEYWORDS: Photocatalytic, TiO₂, SiO₂, VOC_s, Rhodamine B, EDAX.

I. INTRODUCTION

Concrete, a composite material that consists essentially of a binding medium, such as mixture of Portland cement and water, within which are embedded particles or fragments of aggregate usually a combination of fine and coarse aggregate. Titanium dioxide occurs in nature as the well known minerals rutile, anatase and brookite. Anatase form of TiO₂ is used in this concrete. Silicon dioxide, also known as silica, silicic acid or silicic acid anhydride is an oxide of silicon with the chemical formula SiO₂, most commonly found in nature as quartz. Titanium dioxide (TiO₂), a photocatalytic material which has been investigated for the self cleaning properties and known as effective material for reducing harmful gases and pollutants such as sulphur oxide (SO_x), nitric oxide (NO_x), volatile organic compounds (VOC_s) etc.

Photocatalytic materials helps to mitigate ultraviolet rays. During vehicular emission by human activity the concrete gets pollutants like nitrogen dioxide, sulphur dioxide, carbon dioxide and at the same time ultraviolet radiation (UV) from sunlight reaches the surface of concrete and photocatalytic activity takes place. The photocatalytic activity consists of different steps: the photoactive TiO₂ at the surface of the material is activated under the influence of ultraviolet light and, subsequently, the pollutants are oxidized due to the presence of the photocatalyst and precipitated on the surface of the material. Finally, they can be removed from the surface by the rain or cleaning or washing with water and self cleaning action takes place. Again the concrete gets ready for undergoing both photocatalytic and self cleaning activities.

Photocatalytic reaction uses the energy from ultraviolet rays to oxidize organic compounds. This reaction is able to accelerate the process of natural oxidation and faster pollutant decomposition. Photocatalytic activity have two primary benefits which are kept surface free of dirt and ensure a cleaner environment. And in this new concrete made by introducing SiO₂ along with TiO₂ into concrete the strength of concrete increases. And it not only keeps itself clean but also remove pollutants from the air and hence called modified self cleaning concrete using silicon dioxide.

II. RELATED WORK

The concept of self cleaning concrete was first introduced by Luigi Cassar in 1997 and he received European Inventor Award in 2013. Together with his team at the Italian cement manufacturer Italcementi, Luigi Cassar developed an innovative cement mixture that is self cleaning and purifies the air. The cement uses sunlight to break down

pollutants into less harmful substances. In [1] the properties of titanium dioxide nanoparticles on properties of binary blended concrete are evaluated. In [2] Anatase form of TiO_2 was used as the better form sourced from a commercial source because of best photo catalytic ability for improving indoor air quality. The degradation process under laboratory conditions was studied using chemiluminescence analysis method for measuring the performance of photocatalytic active concrete products. Paper [3] gives a short overview of the photocatalytic principle applied in concrete and recent photocatalytic applications for air purification in Belgium. In [4] photocatalytic activity is demonstrated by using RhB (Rhodamine dye) solution on top side of concrete. In [5] article focuses on the self cleaning behaviour of different opaque envelope materials coated with titanium dioxide based sol-gel products, proposing a convenient and effective alternative to traditional facade washing for maintenance purposes. In [6] technology can be applied by incorporating TiO_2 directly into concrete or by incorporating TiO_2 into photocatalytic coatings for concrete specimens. In paper [7] self cleaning activity of concrete was determined by using EDAX test. In [8] applying titanium dioxide topavement of road helps to remove emission pollutants right next to the source, near the vehicles that drive on the pavement itself. In [9] self cleaning concrete that contains those photocatalysts will be energized by ultraviolet (UV) radiation and accelerates the decomposition of organic particulates. Thus, the cleanliness of the building surfaces can be maintained and the air surrounding air pollution can be reduced.

III. METHODOLOGY

Various materials like cement, coarse aggregate, fine aggregate, water, titanium dioxide and silicon dioxide, rhodamine blue are used. Modification to self cleaning concrete was done by casting concrete cubes and mortar cubes by adding varying percentages of TiO_2 and SiO_2 (0-3.5%, in varying percentage of 0.5%, with 1:1 proportion) in M_{20} grade of concrete and various tests were conducted.

Compressive strength test

The cubes of standard size 150 x 150 x 150 mm was used to determine the compressive strength of concrete. And the specimens were allowed for 7 days of curing. Three specimens were tested for 7 and 28 days compressive strength. TiO_2 and SiO_2 dosage was applied on the rate of 0.5% increasing up to 3.5% in M_{20} grade of concrete. Slump cone test was used for determining workability of concrete cube specimens.

Rhodamine B decolourisation test

Concrete containing TiO_2 photo catalysts have been evaluated based on decolourization under sun light, a standard test for self cleaning materials. Experimental data are discussed in relation to dye decolourization of 0% and 2.5% of TiO_2 and SiO_2 replaced concrete cube sample placed under sunlight. On the surface of the casted concrete cubes 1ml of Rhodamine dye is dropped on each cube sample and placed under direct sunlight and the results are recorded.

EDAX test

Four Mortar cubes of size 1 X 1 X 0.5 cm were prepared for conducting EDAX test. Mix cement, sand, and the combination of titanium dioxide and silicon dioxide (1:1 proportion) in dry condition with a trowel for 1 minute and then add water. Selfcleaning capability of the mortars with 2.5% dosage of TiO_2 and SiO_2 was evaluated by monitoring the Carbon, Sulphur and Oxygen content present in the concrete specimens by conducting EDAX (Energy Dispersive Analysis of X-rays) test. The four mortar cube samples were casted namely as sample A, sample B, sample C, sample D. Sample A was tested for the presence of titanium content in sample and pollution factor. Samples B, C, D were allowed to get pollution. Then sample B was kept inside the laboratory itself. Sample C & D were exposed to UV radiation from sunlight for 4 hours. After 4 hours of radiation sample C was kept in laboratory and sample D gets washed then allowed to monitor the elements present in the sample. Results were analysed after 24 hours such as before pollution, after pollution, under UV radiation and after that washing can be done.

IV. EXPERIMENTAL RESULTS

The results obtained by conducting various tests are as follows,

Compressive strength test

Cube specimens of 48 nos. were casted, using TiO_2 and SiO_2 (1:1 proportion ,0%,0.5%,1%,1.5%,2%,2.5%,3%,3.5%) in M_{20} mix. Figure below shows the results obtained from compressive strength test.

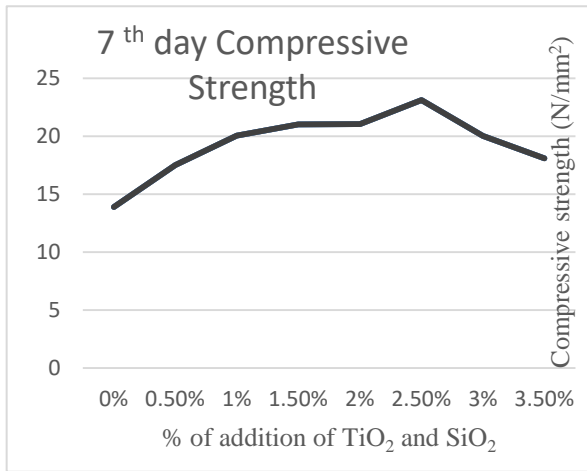


Figure 1:-7th day compressive strength

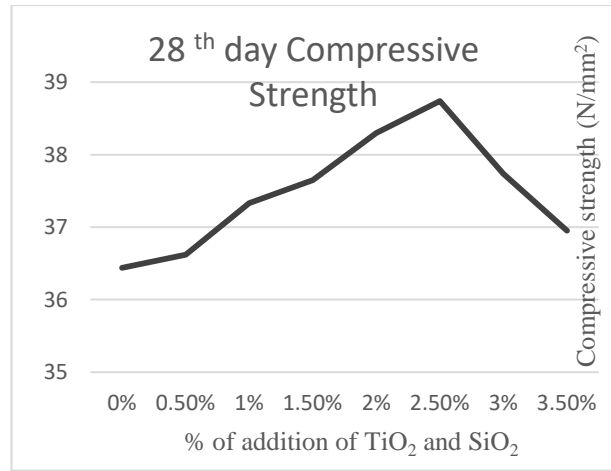


Figure 2:-28th day compressive strength

Rhodamine B decolourisation test

The observation shows that the value of decolourization increases when the percentage of TiO₂ and SiO₂ increases. The decolourisation in cube samples with 2.5% of TiO₂ and SiO₂(ie, modified self cleaning cube sample) is very higher when compared to normal cube samples. And after 24 hours the colour of Rhodamine B dye fades ie, self cleaning action takes place.



Figure 3:- Normal cube samples kept under sunlight after 24 hours



Figure 4:- Modified self cleaning cube sample kept under sunlight after 24 hours

EDAX test

The results obtained by conducting EDAX test are as follows,

All samples used for EDAX test are modified self cleaning mortar cube samples with SiO₂ under different conditions.

Sample A – Sample without pollution.

Sample B – Sample with pollution.

Sample C – Polluted sample under sunlight.

Sample D – Polluted sample after washing.

The percentages of elements are shown in as graphical representation.



Figure 5:- Mortar cube samples used for EDAX test

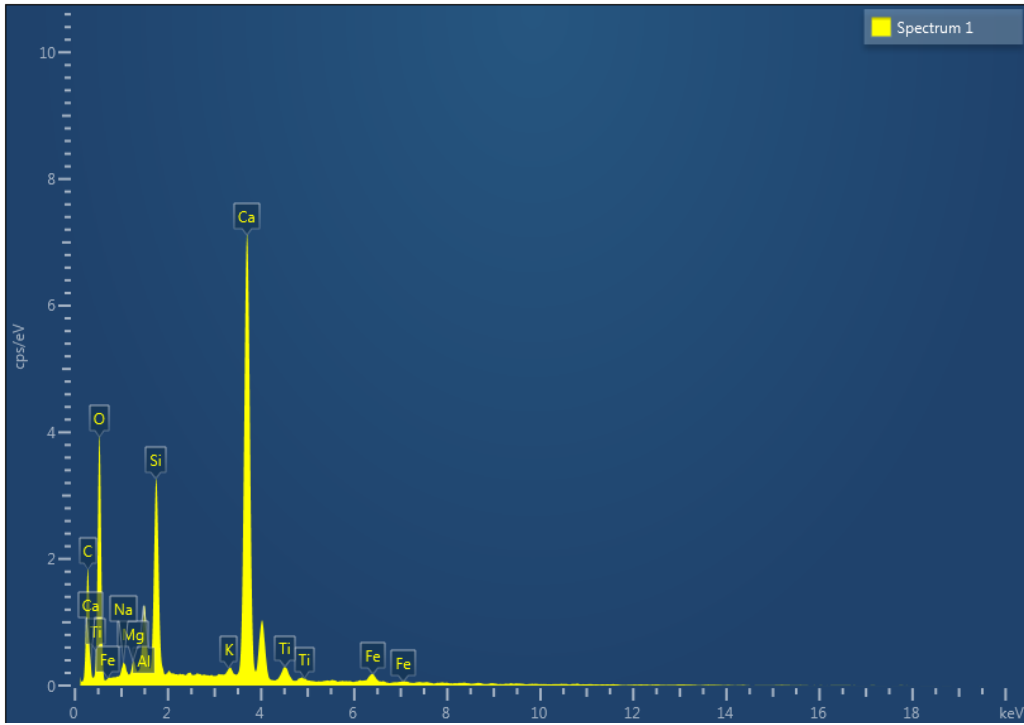


Figure 6:-Test results for mortar cube A

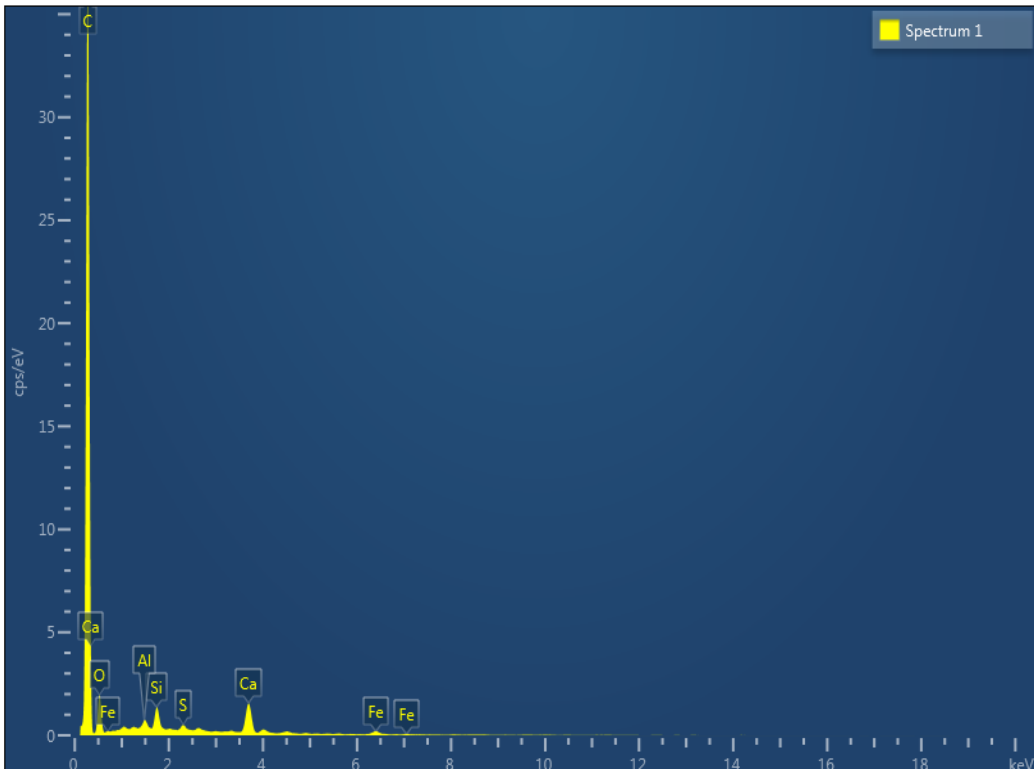


Figure 7:-Test results for mortar cube B

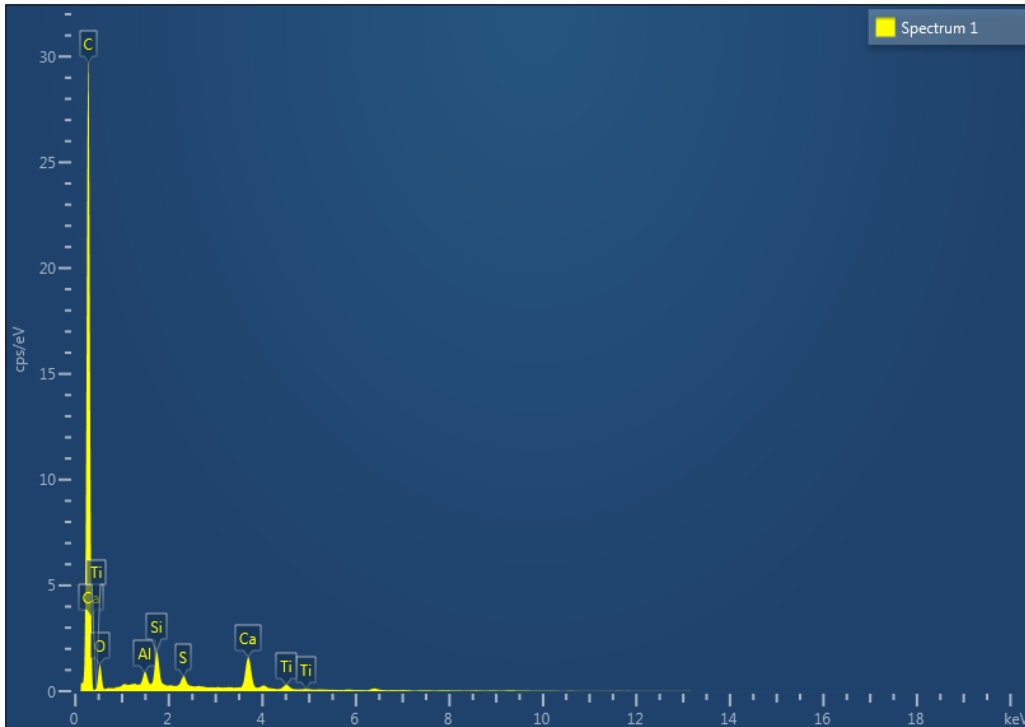


Figure 8:-Test results for mortar cube C

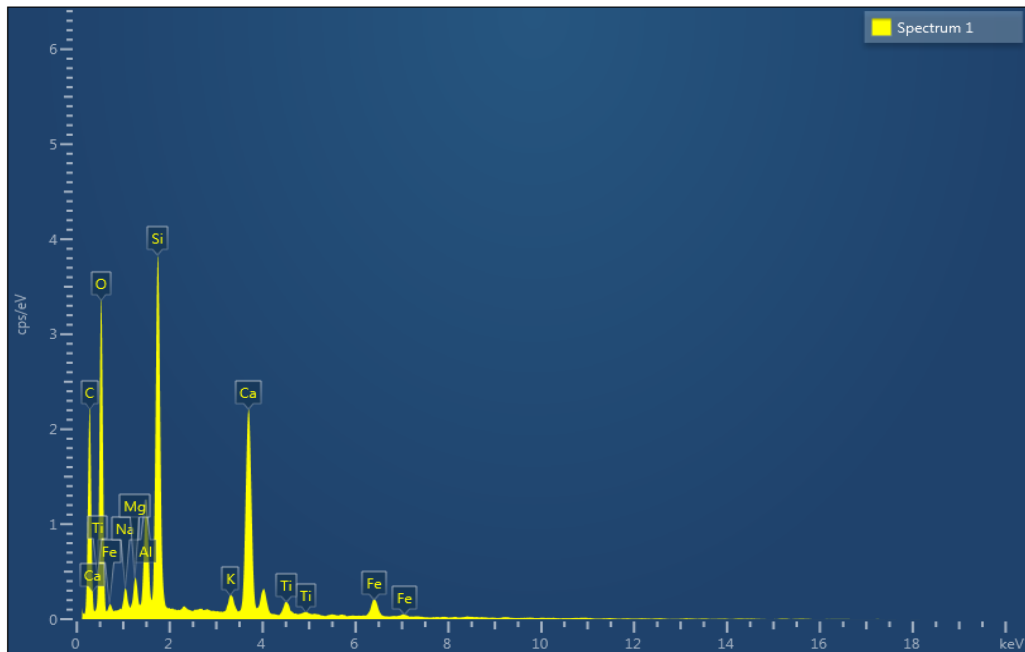


Figure 9:-Test results for mortar cube D

V. CONCLUSION

The concrete in which cement is partially replaced by 2.5% of titanium dioxide and silicon dioxide shows optimum value in compressive strength observed at 7th day and 28th day and beyond it decreases. The Rhodamine B decolourization test results show that in self cleaning concrete, decolourization occurs when the cube kept in 24 hour sunlight exposure. But in normal concrete cube no change occurs to the colour of cube.

EDAX test shows the good behaviours of the self cleaning concrete by means of photocatalytic activity and self cleaning activity based on the tested values. Presence of pollutants like Carbon and Sulphur are having higher values in sample B and hence no action takes place. Sample C was kept under sunlight and value of pollutants decreases and only photocatalytic action takes place. And sample D was kept under sunlight and later subjected to washing and hence amount of pollutants decreases greatly compared to sample C because both photocatalytic activity and self cleaning action takes place. Hence modified self cleaning concrete using SiO₂ helps to remove pollutants from the air and even cleans the polluted surfaces. And it also helps to reduce atmospheric pollution and global warming and hence provide a greener and eco-friendly environment.

REFERENCES

- [1] ShadiRiahi and Ali Nazari. "The effects of TiO₂ nanoparticles on properties of binary blended concrete", Journal of Composite Materials Vol.45,May 2010.
- [2] ArafAawadalla, Muhammad FauziMohd Zain, Abdul Amir H. Kadhun, "Titanium dioxide as photocatalyses to create self cleaning concrete and improve indoor air quality", International Journal of the Physical Sciences, Vol. 6 (29) , pp. 6767-6774,Malaysia, 16 November, 2011.
- [3] EliaBoonen and Anne Beeldens "Recent Photocatalytic Applications for Air Purification in Belgium", Young Researchers Seminar, Demark, Jan.2013.
- [4] Ranjit K Odedra, K A Parmar ,Dr. N K Arora "Photocatalytic self cleaning concrete ",International Journal for Scientific Research & Development Vol.1, Issue 11,Sept.2014
- [5] A.Andaloroa, E.S. Mazzucchellia, A. Lucchinia,"Photocatalytic self-cleaning coatings for building facade maintenance-Performance analysis through a case-study application", Journal of Facade Design and Engineering 4, Newyork, March 2016.
- [6] Adnan Mujkanovic,DzenanaBecirhozic,NevetMerdcic "Self-cleaning concrete – a construction material for building cleaner world", 20th International Research/Expert Conference, Mediterranean Sea Cruising, Volume 5, Issue 3, March 2018.
- [7] R.Sakhthivel, T.ArunKitcha ,S. Aravindheth,al., "Experimental study of photocatalytic concrete using Titanium dioxide, "International Journal for Innovative Research in Science & Technology, Volume 4 , Issue 11,April,2018.
- [8] S.S.Janagan, K.Saravanakumar, G.Gnana Prakash, "An experimental investigation of photocatalytic concrete, International Journal of Advance Engineering and Research Development ,Volume 5, Issue 04, April,2018 .
- [9] Rajamuniasamy, Mercy, Praveen, "Experimental study on self cleaning concrete by replacing cement by titanium dioxide",International journal of scientific research and review, Vol 7, Issue11, June 2018.