

Titanium Dioxide – A Boon to Contravene the Increasing Levels of Air Pollution in Indian Cities - A Review

Alka A. Avasthi¹, Sampat N. Nanaware², Prasad B. Joshi³, Vijeta N. Kundlikar⁴,
Pratibha B. Patil⁵

Head of Department, Department of Civil Engineering¹

Lecturer, Department of Civil Engineering^{2,3,4,5}

Pimpri Chinchwad Polytechnic, Nigdi, Pune, Maharashtra, India

Abstract: *The Construction Industry has always been rightly blamed for working against the environment because of the concretization activity. So civil Engineers and architects around the world are continuously investigating and working on different construction materials for improving their properties and making them environmentally sustainable. Along with concretization the major cause of pollution are the petrol and diesel vehicles emitting NiO_2 in the environment. Hence a very important question is whether we have a solution to this problem? Scientists around the world are finding solutions to this everlasting question. One such material being used is Titanium dioxide which has the ability of absorbing nitrogen dioxide from the environment. As per the studies it is found that the effect of TiO_2 is more effective in the presence of sun. Already this technique is being used in some of the countries like Mexico, China, Germany etc. It is used in different materials like tiles and paints. As a photo catalyst, titanium dioxide can be added to paints, cements, windows and tiles in order to decompose environmental pollutants. With a legacy of 100 years of safe commercial use, titanium dioxide is only going to become more vital as our environment faces greater challenges from a growing population. Smog also causes a lot of diseases which can be fatal [1]*

Keywords: Smog, Pollution, Construction, Building, Sustainability, Nitrogen Dioxide, etc.

I. INTRODUCTION

Air pollution is a major cause of concern globally. Due to increasing population and less area many cities are becoming congested leading to concentrated air pollution zones. Scientists and researchers universally are continuously working towards finding a solution to this ever-increasing problem. Some of them have come up with a chemical photocatalytic titanium oxide. Photo catalytic Titanium dioxide is an effective chemical in smog abating in the presence of sunlight. When added in fixed proportions in cement it improves the mechanical properties of cement. Hence researchers worldwide have come up with different ways and means of using Titanium dioxide.

Some used it as a partial replacement to cement. Some used it in paint due to its reflective and refractive characteristics. It is also used in tiles to be fixed on pavements. This compound has been used worldwide in different forms. The air quality index of the countries using it for purifying the environment is better than India.

II. LITERATURE REVIEW

Pietrzak et al. (2016) investigated the properties of Titanium dioxide when added as an additive in cement it helped in improving the air quality by absorbing harmful substances present in the air and converting them into non-hazardous compounds in the presence of ultra violet rays. Due to the photo catalytic properties of Titanium dioxide the harmful nitric oxide presents in the atmosphere, which is due to fuel combustion by road vehicles and industries. This Nitric oxide (NO) is converted into the non-hazardous nitrogen dioxide. Hence keeping the

aesthetic value of the concrete buildings intact. The author concluded that the presence of photo catalytic Titanium dioxide in cement improves its early strength but did not comment on its later strength[2].

Joshaghani, Alireza(2018) also presented a study where they investigated the pore structure of concrete after partially replacing cement with Titanium dioxide and found out that there was improvement in the pore structure of concrete containing titanium dioxide as a partial replacement. The porosity of the concrete also reduced thus improving the mechanical and durability properties of concrete [3].

Diana-Maria Mircea(2019) proposed manufacturing concrete using titanium dioxide and called itself cleaning concrete as it cleaned the atmosphere around and hence preferred it for being used in Landscaping. She further provided evidence of such concrete maintaining its aesthetic value over the years to come[4].

George Diamantopoulos et.al (2020) investigated its use as an additive to cement and hence concluded that though Titanium dioxide improves the mechanical properties of concrete in terms of the early strength gain, it reverses the results later. Hence though its early strength increases its hydration process in the later stages is hampered due to its property of not allowing water molecules to reach the unhydrated cement molecules[5].

III. METHODOLOGY

Titanium is one of the most common metals on the earth surface, but it does not occur naturally in its elemental form. Titanium dioxide – also known as titanium (IV) oxide or titania – is the naturally occurring compound created when titanium reacts with the oxygen in the air. As an oxide, titanium is found in minerals in the earth's crust. It also found with other elements, including calcium and iron. Its chemical formula is TiO_2 , which means it consists of one titanium atom and two oxygen atoms (hence dioxide). TiO_2 is typically thought of as being chemically inert, meaning it doesn't react with other chemicals and is, therefore, a stable substance that can be used in many different industries and for a variety of applications. Nano, or ultrafine TiO_2 comprises of primary particles sized less than 100nm. In this grade, titanium dioxide is transparent (colourless) provides improved UV scattering and absorbing properties compared with larger particle-size, pigment-grade TiO_2 . The smaller particle size also helps in improving the pore structure. It has a very high refractive index and hence it is able to scatter visible light and also provides a surface which is reflective. It can also be used as a coating for wind turbines and plastic window frames, providing both a suitable white colour and protection from UV degradation.

Different methods were proposed for the application of titanium dioxide to the structures and buildings. The most popular method was to use it in paint so that it could be applied evenly on the surface and due to its spreading characteristic, it could cover a larger area. Thus, being cost effective. Some researchers proposed using it as a partial replacement to cement so that along with pollution control it could also improve the mechanical and durability properties of concrete. The third method proposed was sprinkling titanium dioxide on the surface of wet concrete.

IV. RESULTS AND DISCUSSION

Earlier commercial paint manufacturers were using lead as a whitener. It is a very highly toxic material as it was very cost effective, realising little about the hazardous effect it would have on the health of the inhabitants. Despite all its disadvantages it also did not provide a reflective platform similar to that of titanium dioxide. Only being cost effective, would not solve the problem. Hence researcher's world-wide came up with an alternative in terms of Titanium dioxide. It was already a known fact that titanium dioxide is a non-toxic, non-reactive substance that provides a brightening effect to the platform it is used in and also has reflective properties. It also spreads evenly on the surface it is applied and can also absorb harmful ultra violet rays.

This is a material which when mixed with paint, it provides a surface which absorbs pollutants from the atmosphere and provides a smog free environment. So, with congested cities dealing with air pollution have proposed buildings coated with photo-catalytic titanium dioxide to absorb smog and other pollutants in the air in the presence of sunlight. The mass-produced tiles, created by Berlin-based company, are coated with titanium

dioxide, a pigment that can act as a catalyst for chemical reactions when it's activated by sunlight. When UV rays hit the tiles, a reaction occurs, converting mono-nitrogen oxides (the substances that make smog smoggy) into less harmful substances.

Countries like Italy are using titanium dioxide in preparing photo catalytic concrete which can break nitric oxide into nitrogen oxides in the presence of sunlight. These oxides breakdown in the presence of sunlight into non-toxic chemicals like water, carbon dioxide, calcium nitrate etc.

Out of the various methods proposed for using titanium dioxide the best method for removing hazardous compounds like nitric oxide from the atmosphere was using titanium dioxide as 5% replacement in cement. This method along with providing self-cleaning effect also resisted wear and tear of the surface and also lasted for a longer duration on the surface.

V. CONCLUSION

Titanium dioxide a nano material is being used in many countries in paint, tiles, pavements etc. Even India is battling with the ever-increasing problem of smog, which is mainly due to burning agricultural waste in the open. Resulting in high levels of pollution, leading to hazardous diseases and challenges to the health of the citizens. As India is a very highly populated country titanium dioxide can also be used which will provide a shield from pollution and reduce the pollution levels by absorbing the pollutants from the atmosphere. With a legacy of 100 years of safe commercial use, titanium dioxide is only going to become more vital as our environment faces greater challenges from a growing population.

As a widely used substance with multiple applications, research is being carried out to improve the production process to reduce the levels of chemicals used and waste produced, and to recycle any by-products. Titanium dioxide is also being considered as being used as a partial replacement to cement and some researchers have achieved positive results in terms of mechanical and durability properties. In its photo catalyst form titanium dioxide can also be used in manufacturing self-cleaning concrete which will clean the environment and be used in Landscaping and to improve aesthetic value of structures and Buildings. So, in countries like India which are overpopulated such solutions should be accepted and implemented with immediate effect. Earlier Titanium dioxide was itself considered as a hazardous compound itself, leading to cancer. But continuous investigations of the compound negated this myth. Lot of researchers put forth evidences proving the same. Hence misconceptions sometimes in the society pose a bigger challenge.

One of the major challenges faced by us in India is the deteriorating air quality Index, specifically in the northern states. Hence as per the present situation in India where Air Quality index is deteriorating by each passing day, it is proposed that such solutions should be paid heed and utilised for betterment of the ecosystem and for providing a sustainable environment.

REFERENCES

- [1] R. A. Silva et al., "Global premature mortality due to anthropogenic outdoor air pollution and the contribution of past climate change," *Environ. Res. Lett.*, vol. 8, no. 3, 2013.
- [2] A. Pietrzak, J. Adamus, and B. Langier, "Application of titanium dioxide in cement and concrete technology," *Key Eng. Mater.*, vol. 687, no. April 2016, pp. 243–249, 2016.
- [3] A. Joshaghani, "Evaluating the effects of titanium dioxide (TiO₂) and carbon-nanofibers (CNF) as cement partial replacement on concrete properties," *MOJ Civ. Eng.*, vol. 4, no. 1, pp. 29–38, 2018.
- [4] D. M. Mircea, "Self-Cleaning Concrete for Landscaping Applications," *MATEC Web Conf.*, vol. 289, pp. 1–4, 2019.
- [5] G. Diamantopoulos et al., "The Role of Titanium Dioxide on the Hydration of Portland Cement: A Combined NMR and Ultrasonic Study," *Molecules*, vol. 25, no. 22, 2020.
- [6] URL: <http://worldcat.org/issn/19966814>