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# A REVIEW ON TITANIUM DIOXIDE - A STUDY OF SELF-CLEANING CONCRETE

**[1]Prof. Rakesh Kumar, [2]Ms. Gauri Chandgude, [3]Mr. Pravin Gond, [4]Mr. Aditya Shete, [5]Ms. Siddhika Jadhav**

[1] Assistant Professor APCOER, [2] Student of APCOER, [3] Student of APCOER, [4]Student of APCOER, [5]Student of APCOER

[1] Civil Engineering Department,

[1] Anantrao Pawar College of Engineering and Research, Pune, India

***Abstract:*** Building technology relies heavily on the use of concrete, which is the most commonly utilized construction material. However, cement production releases large amounts of carbon dioxide ($CO_2$) into the atmosphere, contributing to increased global warming. Therefore, an alternative environmentally friendly building material such as photocatalyst concrete has been developed. Photocatalytic concrete, with a more environmentally friendly alternative binder, is an innovative building material to replace Portland cement. This technology introduces nanoparticles such as nano clay into the cement paste to improve its mechanical properties. Concrete materials have also been developed to function as self-cleaning building materials. The self-cleaning properties of concrete are provided by the incorporation of photocatalytic materials such as titanium ($TiO_2$). Self-cleaning concrete containing these photocatalysts would be powered by ultraviolet (UV) radiation and accelerate the breakdown of organic particles. In this way, the cleanliness of building surfaces can be maintained and air pollution reduced. This article briefly discusses self-cleaning concrete.

***Index Terms* - Titanium Dioxide ($TiO_2$), Self-Cleaning Concrete, $TiO_2$, Rhodamine B dye, Compressive strength, Photocatalyst.**

## I. INTRODUCTION

The photocatalytic process, discovered 40 years ago, is now being updated as a process that will allow working effectively together to combat the problem of air pollution. A photocatalytic material (Titanium Dioxide $TiO_2$) has been investigated for the self-cleaning process and is known to be an effective material for reducing harmful gases such as sulphur oxides (Sox), VOCs (organic compounds volatile), and NOx. Photocatalytic material ($TiO_2$) is a technology that can help mitigate UV rays. Photocatalytic mechanisms use energy from sunlight (or UV light sources) and convert harmful gases into harmless elements. Photocatalytic materials help to directly mitigate air pollution. When the photocatalytic material absorbs ultraviolet radiation from sunlight, the photocatalytic process of the is completed with titanium dioxide ($TiO_2$).

Unfortunately, the main ingredient in cement contributes to greenhouse gas emissions. Dust emission during the manufacture of cement is one of the major problems facing the industry. A major source of air pollution is concrete dust released by building demolition and natural disasters.

Thus, the use of special admixtures promotes the self-cleaning of large concrete structures, while promotes reactions that also contribute to cleaning up the environment. The properties of photocatalysts include photocatalytic water and air purifiers, photocatalytic self-cleaning, and antibacterial effects. Its application is limited due to chemical engineering limitations such as photocatalyst support or separation of photocatalyst from effluent.

## II. OBJECTIVES

- To study how $TiO_2$ can be used as a long-lasting material.
- Investigating the Self-Cleaning Performance of Concrete with Titanium Dioxide ($TiO_2$) Addition.
- Evaluating the Effect of Titanium Dioxide ($TiO_2$) Addition on the Compressive Strength of Concrete.

## III. Literature Review

Concrete is a widely used construction material, but it can accumulate dust, dirt, and other pollutants that lead to deterioration and loss of aesthetic appeal. Self-cleaning concrete is a promising solution that can clean itself through a photocatalytic reaction. One approach to achieve this is by replacing a portion of the cement with photocatalytic materials, such as titanium dioxide ($TiO_2$). In this literature review, we will summarize the findings of several experimental studies that investigated the use of $TiO_2$ in self-cleaning concrete.

The amount of $TiO_2$ added to concrete can affect its self-cleaning ability. Generally, higher $TiO_2$ concentrations lead to better photocatalytic performance, but excessive amounts can negatively impact the mechanical properties of the concrete. Several factors can influence the effectiveness of $TiO_2$ in self-cleaning concrete, such as the type of pollutant, the intensity and duration of UV light exposure, the surface texture of the concrete, and the environmental conditions. $TiO_2$-modified concrete has potential applications in various settings, such as highways, bridges, buildings, and public spaces. However, further research is needed to evaluate its long-term durability, cost-effectiveness, and scalability. $TiO_2$ is a photocatalytic material that can break down pollutants on the surface of concrete when activated by UV light. The resulting reaction produces hydroxyl radicals that can oxidize organic compounds and decompose them into harmless products, such as carbon dioxide and water. The use of $TiO_2$ in self-cleaning concrete has several advantages, including the reduction of air pollution, the prevention of microbial growth, and the maintenance of a clean and aesthetically pleasing surface.

Prathamesh R. Ingole et al. (2022) conducted an experiment to evaluate the effect of adding $TiO_2$ to concrete on its self-cleaning ability. The researchers prepared concrete samples with varying amounts of $TiO_2$ and assessed their self-cleaning properties using a photocatalytic degradation test. The results showed that the addition of $TiO_2$ improved the self-cleaning ability of concrete.

In a similar study, T Vignesh et al. (2018) prepared self-cleaning concrete by replacing cement with $TiO_2$ nanoparticles and evaluated its self-cleaning ability. The results showed that the $TiO_2$-modified concrete had a higher self-cleaning efficiency than regular concrete, indicating that $TiO_2$ can enhance the self-cleaning ability of concrete.

## IV. Methodology

1. **STUDY OF MATERIALS:**
   The materials used in this research are Ordinary Portland Cement - 53 Grade, Fine Aggregate with a size less than 4.75mm, Coarse Aggregate with a maximum size of 20mm, Titanium Dioxide with an average particle size of 35nm, and Rhodamine B-dye with a red/violet color.

2. **BATCHING OF MATERIALS:**
   In this research, the materials are batched using the weigh batching method.

3. **MIX DESIGN:**
   For 1 cubic meter of concrete, the mix design is as follows:
   Cement: 425.73 kg/m3
   Fine Aggregate: 630.45 kg/m3
   Coarse Aggregate (20mm): 1140.8124 kg/m3
   Water: 191.58 kg/m3
   The ratio of Cement: F.A: C.A: Water is 1:1.48:2.67:0.45.

4. **CASTING:**
   Cube specimens with dimensions of 150mm x 150mm x 150mm are cast. The concrete mix is prepared with partial replacement of cement with $TiO_2$ in varying percentages of 1%, 2%, 3%, 4%, and 5%.

5. **CURING:**
   The concrete specimens are cured to achieve the desired properties for their intended use. This is done by providing proper moisture, temperature, and time.

6. **TESTING:**
   Two tests are carried out on the hardened concrete:

**COMPRESSIVE STRENGTH TEST:** This is the most common test for hardened concrete and is carried out on Universal Testing Machines (UTM) or Compression Testing Machines (CTM). The dimensions of the specimens used for the test are 150mm x 150mm x 150mm.

**RHODAMINE B DYE DECOLORIZATION TEST:** This is a standard test for self-cleaning cementitious material. In this test, a few drops of Rhodamine B-dye are dropped on the surface of each cube. After a few hours, the cubes are exposed to light, and the Rhodamine B-dye decolorizes.

## V. CONCLUSION

The addition of titanium dioxide to concrete has demonstrated the ability to break down pollutants, such as nitrogen oxides when exposed to sunlight. This photocatalytic process is effective in removing surface contaminants from the concrete, leading to a cleaner and more sustainable environment.
The reading also reveals that the use of titanium dioxide in self-cleaning concrete has the potential for reducing maintenance costs and extending the lifespan of infrastructure. The self-cleaning properties of the concrete can prevent the build-up of dirt, grime, and other pollutants, which can cause discoloration and degradation of the surface.
Overall, the findings of this study suggest that the use of titanium dioxide in concrete can contribute to a cleaner and more sustainable environment while also providing cost-saving benefits. Further research and development in this area can lead to the widespread adoption of self-cleaning concrete as a solution for improving the durability and maintenance of infrastructure.

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