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Research Article

Study on the Behavior of Self-Cleaning Impregnated Photocatalyst (Tio_2) with Cement Mortar

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Cement-based materials are increasingly and widely employed in infrastructure development; however, they pollute our environment by generating carbon dioxide, which is detrimental to our civilization. In self-cleaning concrete, photocatalysts accelerate the decomposition of organic particles; thus, photocatalytic degradation of gaseous pollutants could reduce pollution. The incorporation of photocatalytic components enhanced the mechanical self-cleaning properties of cement mortar. In this study, 4–6 percent by weight of rutile TiO_2 was added to mortar, and the results were compared to those of a control sample. On the proposed mortar cubes, both fresh mortar and hardening mortar experiments were conducted. Because the initial and final setting times of TiO_2 differ from those of conventional cement mortar, the surplus TiO_2water-cement ratio had to be modified. The adaptability of the sol-gel method enables the use of various process parameters to influence the properties of the produced TiO_2 nanoparticles. The compressive strength was calculated for 7, 14, 21, and 28 days, and an ultrasonic velocity test was performed after 28 days. On mortar samples, acid and sulfate attack experiments were performed. The M-3 mortar mixture containing 5% rutile exhibited the highest level of strength compared to the other mixtures. The M-3 exhibits a strength that is 10.96% greater than that of the control mix. The impact of acid and sulfate attack on the strength of mix M-2 is relatively modest in comparison to other mixtures. Using RhB (rhodamine color) discoloration under UV light, such as sunlight, the photocatalytic mortar is concentrated; a typical test for self-cleaning cementitious materials reveals the presence of more photocatalytic material, which yields the best results.

1. Introduction

Air pollution is a big environmental problem all over the world. Vehicle emissions of several air pollutants pose risks to human health and the environment every day. The rising cost of construction is mostly attributable to the rising cost of living generally and the rising demand for naturally occurring raw materials. Reusing and recycling landfill trash must be prioritized as a viable construction material option [1]. Cultural heritage (CH) preservation and protection is a key issue that concerns governments all over the world. A major concern is the degradation of its materials, such as natural stones and mortar. Numerous cultural artifacts may be lost due to biological colonization, as well as the urban area and the quality of air in particular. To prevent biodeterioration and soot formation on CH artifacts, which alters both their aesthetic and physical-chemical aspects, chemical treatments such as water repellent and cleaning agents are frequently utilized as conservation treatments for historic monuments [2]. Water repellents, for example, do not provide long-term protection and must be used frequently [3]. Furthermore, cleaning techniques and the aging of shielding coverings may cause those materials to change even more. Thus, those maintenance methods should be minimized, taking into account their potential invasiveness and environmental impact, to prevent or lessen aesthetic and physical-chemical deterioration. As a result, novel technologies are aimed at preventing deterioration, with a particular focus on novel nanomaterials [4–8].

Due to photocatalysis, nanocrystalline TiO_2 has been utilized in self-cleaning construction materials (primarily concrete, stone, and mortars) [4–8]. Numerous evaluations of TiO_2's self-cleaning action, focusing on its photocatalytic activity, have been published [9–11]. The mortar is a workable mixture of cement, grit, and water that is used to fill irregular gaps and spaces and bind masonry units together. To create a flawless surface and protect the structure, cement mortar is frequently used to plaster wall structures [12]. Cement plaster, on the other hand, is weak, accumulates a great deal of water and air pollutants, and degrades the structure, leading to surface cracks and dampness. Cement plaster is mixed with nanoparticles and pozzolanic elements to combat these defects [13]. The purpose of this experiment is to synthesize nanoparticles in cement mortar and investigate their effects. Due to the photocatalytic properties of TiO_2, this study also contributes to the reduction of carbonic acid gas emissions into the atmosphere. A new object has begun to appear on new infrastructure that simultaneously cleans itself and filters the air around it. Self-cleaning materials could contribute to a clearer city by reducing air pollution levels. Cement, or calcium-silicate-hydrate (C-S-H) products, is utilized to produce photo-catalytic nanoparticles with an ultrasmooth surface, such as titanium oxide [14]. Because of its ultrasmooth surface and photocatalytic properties, the rain will wash away the impurities. This innovative mortar could be used as a self-cleaning coating for urban structures [15]. Titanium oxide in its rutile phase possesses the greatest photoactivity as an environmental depollutant. A photocatalytic reaction is illustrated in Figure 1.

Because of its many advantages, such as strong oxidizing power, antibacterial qualities, self-cleaning and depolluting capabilities, nontoxicity, chemical stability, and a high index of refraction, TiO_2 as a photocatalyst appears to be a very promising material. When the hydrophilic or hydrophobic TiO_2 cement surfaces are subjected to irradiation, the catalyst is photostimulated, and the photocatalytic activity commences [13]. Photocatalysts, when exposed to UV light, degrade organic substances including dirt (soot, oil, filth, and particulates), living organisms (mold, bacteria, algae, and allergens), airborne contaminants (VOC, cigarette smoke, NOx, and SO_2), and odor-causing components. Smog is formed when nitrogen oxides (NOx) and volatile organic compounds (VOCs) in polluted urban air break down in the presence of sunlight, and photocatalytic air cleaning can reduce these levels, making cities safer places to live. In the presence of moisture in the air, titanium dioxide nanoparticles absorb UV radiation and function as a catalyst to form reactive hydroxyl (OH) radicals. Most contaminants can be oxidized and destroyed by these radicals [14, 15]. The creation of an acid arises from the photocatalytic oxidation of NO (HNO_3). Most cement formulations are alkaline, which causes the acid to be neutralized and, as a result, the substrate to slowly erode. Carbonate is a desired addition to other product compositions to increase porosity and neutralize the acid. The efficacy of photocatalytic air cleaning technology based on titanic oxide nanoparticles was investigated in this project. Debris (soot, oil, filth, and particles), microorganisms (mold, algae, bacteria, and allergens), airborne pollutants, and odor-causing substances can all be broken down by photocatalysts when exposed to UV light. It would appear that most inorganic pollutants, such as rust stains, do not require a catalyst for their formation [17]. Catalyzing the decomposition of the materials results in the formation of oxygen, carbonic acid, gas, water, sulfate, nitrate, and other inorganic molecules. Self-cleaning materials based on photo-catalytic reactions are employed in a wide variety of consumer products. Photocatalysis has emerged as a promising approach to address contemporary environmental and climatic issues by facilitating the conversion or removal of perilous greenhouse gases from the atmosphere [18].

The physical and mechanical properties of nanocrystalline TiO_2 were investigated by Antonio and Dionisio in mortar specimens made with lime and cement. TiO_2 concentrations are 1, 2, and 5% [19]. The numerous applications of TiO_2 for cleaning the air, self-cleaning, and studying the microstructure of cement mortar were detailed by Marcin et al. 2022. The impact of increasing the TiO_2 concentration from 1 to 5% was discussed. The discussion included thin polycrystalline films as well as powder forms of TiO_2 [20]. Previous studies indicate that TiO_2 is extensively used as a mortar coating. Moreover, no evaluations were conducted until the TiO_2 concentration reached 6%. This article examines the addition of 4–6% rutile TiO_2 (a type of titanium dioxide) to cement mortar and compares the results to those obtained with a control specimen.

The impact of TiO_2 nanoparticles on the self-cleaning and mechanical characteristics of cement was explored by [21]. The hydrothermal method was utilized to synthesize anatase

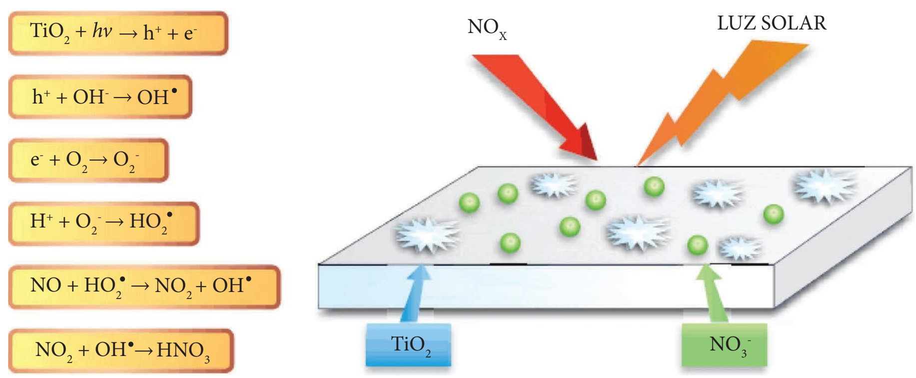


FIGURE 1: Conceptual photocatalytic reaction. Source: [10, 16].

TiO_2 nanoparticles, which exhibited an average particle size of 60 ± 20 nm. The evaluation of the self-cleaning efficacy of TiO_2 cement composite was performed through the decolorization assay of rhodamine B, in contrast to unaltered cement specimens. The findings of the study suggest that an increase in the quantity of TiO_2 nanoparticles in the modified cement led to an enhancement in the self-cleaning characteristic of the samples [22]. Table 1 presents a comparison between the present study and previous research.

2. Materials and Methods

2.1. Study of Titanium Dioxide (TiO_2). After being catalyzed, the materials decompose into oxygen, carbonic acid gas, water, sulfate, nitrate, and other inorganic molecules. To create self-cleaning materials, several commercial goods use photocatalytic processes. Titanium dioxide (TiO_2) can be found in nanocrystals or nanodots with a large surface area. Flamenco, rutile, titania, and di-oxo-titanium are all names for the pigment. It is widely known that nanoparticles of pigment can inhibit bacterial growth and the formation of new cells [13]. Rutile is essentially a white pigment [24]. The particle size of TiO_2 is commonly in the 200–300 nm range. Photocatalytic activity is seen in TiO_2 nanoparticles. Ultraviolet radiation is absorbed by TiO_2 nanoparticles. It is a nontoxic, nonreactive substance.

Antifogging coatings and self-cleaning windows are just two examples of the many ways in which titanium dioxide (TiO_2) is put to use in the building industry [14, 24]. TiO_2 is also employed as a stain remover and as an ingredient in paints, plastics, Portland cement, windows, and tiles, among other things, due to its UV absorption and photocatalytic sterilizing capabilities. The crystalline form of TiO_2 is seen in Figure 2. TiO_2 is frequently utilized to degrade organic compounds in wastewater and gas pollutants due to its photocatalytic activity.

2.2. Synthesis of TiO_2 by Sol-Gel Technique. TiO_2 nanoparticles were made using a sol-gel technique. To make the titanium tetra-isopropoxide (TTIP) combination, 1 mole of TTIP was dissolved in 10 milliliters of ethanol and 35 milliliters of deionized water. The liquid was then agitated at pH 2.5 for 10 minutes. After 50 minutes of magnetic stirring at pH 1 with 1 mole hydrochloric acid (HCl), the liquid was titrated to pH 1. The final solution was a translucent, homogenous, and slightly yellowish liquid. For the gel preparation, the prepared sol was left out at room temperature for 2 hours. The resulting gel was baked for 6 hours at 110 degrees Celsius, dried, and ground into a powder (with a yellowish hue) for use in subsequent characterization and testing of the material's photocatalytic activity.

Titanium dioxide's photocatalytic activity and optical characteristics are improved after calcination, owing to the augmented crystallinity of the nanoparticles [26]. Three batches of the TiO_2 powder were calcined at different temperatures: 300 degrees Celsius, 500 degrees Celsius, and 800 degrees Celsius. A programmable tube furnace was used for the calcination process, with a heating rate of 100°C/hour. After heating to 300 degrees Celsius, 500 degrees Celsius, and 800 degrees Celsius and holding for one hour to evaporate all traces of water and solvent, the mixture was allowed to cool off on its own.

2.3. Properties of Rutile Form of TiO_2. Rutile's structural formula is Ti_2O_4. Rutile is a white 6 pigment categorization powder with a density of 4.5 g/ml and an average crystal size of 20.6–30 nm that is odorless. The rutile phase's melting and boiling points are 1843°C and 2972°C, respectively [24]. It has a low elasticity modulus and a small coefficient of expansion. It can be found in metamorphic rocks, such as eclogite, as well as igneous rocks, plutonic igneous rocks generated at greater depths, as well as kimberlites and other deep-source volcanic rocks, and the ash of plants and animals [27]. Rutile powder has a beautiful white color and is used in paints, plastics, and other applications, where a bright white tone is required. Titanium is a valuable monetary mineral that is mined [28]. The physical characteristics of TiO_2 rutile powder are depicted in Table 2. A sample of TiO_2 rutile powder is displayed in Figure 3.

2.4. Microstructural Characterization. SEM analysis of nano-TiO_2 sample at 1 μm magnification is depicted in Figure 4. Cube-like shape and spherical morphology may be seen in the SEM images of nano-TiO_2 samples. In the SEM analysis, clusters of particles can be seen. The TiO_2 particle

Table 1: Comparison with previous studies over the present study.

Authors	Concentration of TiO_2 (%)	Tests conducted
Pozo-Antonio and Dionísio [19]	1, 2.5 and 5	Microstructure and mechanical properties of mortars
Janczarek et al. [20]	1 to 5	Physical and mechanical properties
Khushwaha et al. [23]	1, 2 and 3	Compressive strength
Current study	4 to 6	Compressive strength, ultrasonic pulse velocity, acid and sulfate attack

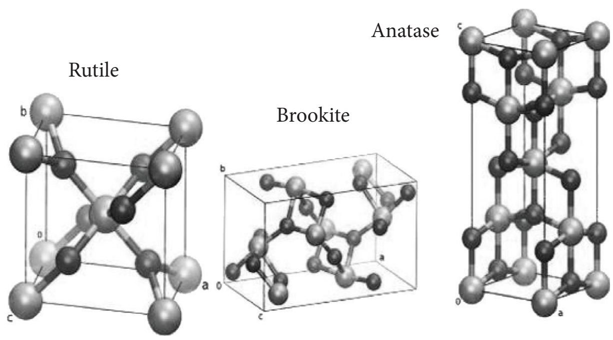


Figure 2: Crystalline form of TiO_2: (a) rutile, (b) brookite, and (c) anatase. Source: [7–9, 25].

Table 2: Physical characteristics of TiO_2 rutile powder.

Color	White
Specific gravity	3.8
Density (g/cm^3)	4.07
Surface area (m^2/g)	54
Purity (%)	98
Diameter (nm)	32

Figure 3: Sample of TiO_2 rutile powder.

size is limited to a maximum of 2 μm. Prepared TiO_2 samples' phase composition was identified by XRD examination. Figure 5 shows an XRD pattern indicative of the formation of an amorphous crystal at 50°C, with a highest peak at 2θ of 20–23 and a weak wide peak at 2θ of 58–65. The phase purity of the produced TiO_2 can be inferred from the lack of any other peak.

2.5. Self-Cleaning Reaction Process. The evaluation of self-cleaning properties in cement mortar is commonly conducted through the examination of the material's capacity to eliminate or decompose organic pollutants under light exposure.

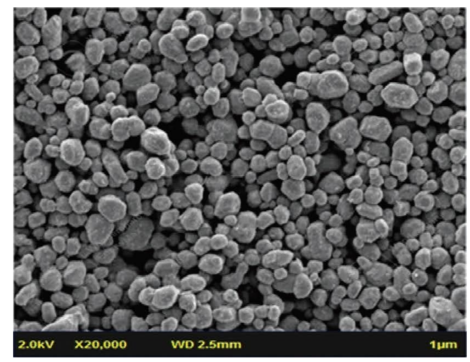


Figure 4: SEM image of TiO_2 at magnification of 1 μm.

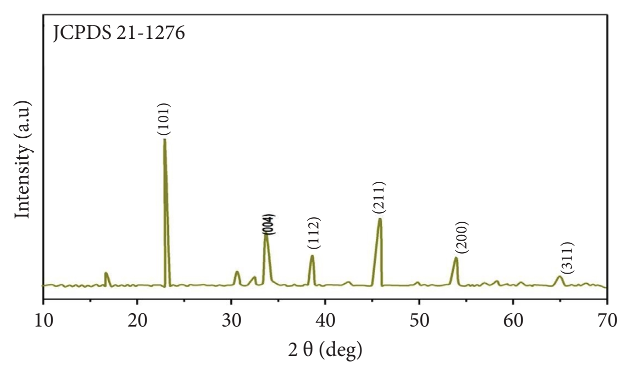


Figure 5: XRD pattern of TiO_2 rutile powder.

The predominant technique employed to assess the degree of self-cleaning efficacy is the evaluation of photocatalytic activity. The photocatalytic reaction of rutile mortar [29] absorbs atmospheric pollutants such as SO_2, NO_2, and other toxic gases. Since rutile titania nanoparticles have been shown to photocatalyze the oxidation of pollutants such as nitrogen oxides (NOx) [30] and volatile organic compounds [31], their use in outdoor air purification was explored in this study. Utilizing nanoparticles of titania for photocatalytic pollution reduction is technically feasible. According to proponents, the application of TiO_2 to exterior walls [32], windows [33], roofs [17], road surfaces [28], and other surfaces will significantly enhance air quality. This initiative aims to demonstrate the significance of photocatalytic TiO_2 nanoparticles' positive effects on air quality [33, 34]. Figure 6 shows the photocatalytic oxidation procedure.

The word photocatalysis could be a compound word made up of two parts: photo and catalysis. Catalysis is a process in which a material helps to control the rate at which a molecule changes its reactants without being altered or burned inside the end product [37, 38]. This chemical is

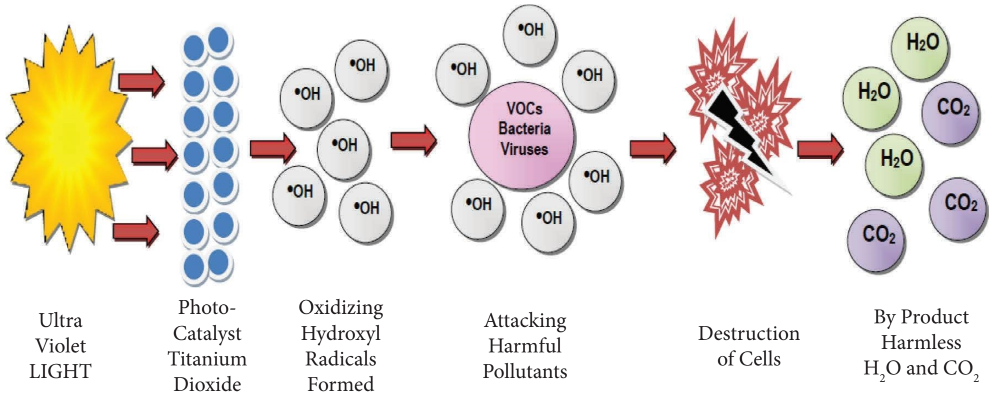


FIGURE 6: Conceptual photocatalytic oxidation process. Source: [35, 36].

assumed to be a catalyst since it speeds up a reaction by lowering the activation energy. When the TiO_2 mortar surface absorbs UV photons in the 50–60 nm range, it performs a photocatalytic activity that decomposes hazardous gases such as SO_2, NO_2, and other VOCs in the atmosphere [39].

2.6. Properties and Components of Mortar. The present research intends to evaluate the self-cleaning capability of modified rutile mortar and compare it to conventional mortar. Rutile mortar (TiO_2) may be utilized as a self-cleaning coating [40]. Photocatalytic air purification can eliminate nitrogen oxides and unstable natural mixtures from polluted urban air. The behavior of TiO_2 should be investigated. While combined with cement mortar at varying concentrations of rutile powder form of TiO_2, such as 4, 5, and 6%, the rutile powder is transformed into rutile oxide. Following are the ratios of various mixtures:

Mix 1: normal cement mortar (1 : 6) ratio (CM)

Mix 2: cement mortar with 4% of TiO_2 (M-1)

Mix 3: cement mortar with 5% of TiO_2 (M-2)

Mix 4: cement mortar with 6% of TiO_2 (M-3)

2.7. Properties of Mortar. Ordinary surface mortar is typically employed to secure structures while also enhancing their exteriors. The self-cleaning capability of modified rutile mortar prevents contamination [41]. Modified rutile mortar is energy-efficient for the building's age. Polluted urban air can have nitrogen oxides and volatile organic compounds removed [32].

2.8. Setting and Hardening of Mortar. There are isolated solid grains in an extremely linked structure when the mortar mixture is in the liquid phase. Hydration begins at the grain's surface. The hydration process is slowed by the thickening of the outer layer. The development of hydrates around each grain transforms the liquid into a solid state [39]. The fluid state's mobility reduces when the water content drops as a result of the reaction. As a result, high-strength concrete with a low water-cement ratio is more susceptible to drying.

2.9. Shrinkage. Early drying sensitivity and rapid autogenous shrinkage are characteristics of high-strength mortar. This result is due to the large amount of paste applied. High autogenous shrinkage causes early-age cracking. This happens in mortars with a low water-cement ratio, as well as mortars that use silica fume.

2.10. Components of Mortar. The four basic components of cement mortar are as follows:

(1) Grade 43 Portland cement
(2) M-Sand
(3) Nano TiO_2 of assorted proportions
(4) Water

The mortar within the masonry protects it from water damage and weathering, so it lasts longer. The key properties of fine mortar should have greater workability, water retention, bond strength, and durability.

2.11. Tests on Materials

2.11.1. Tests on Cement with TiO_2. Cement is a crucial component of mortar, and one of the most important factors to consider when selecting cement is its capacity to improve the microstructure of the mortar. Identifying high-quality cement of the right grade is essential for reaching HSC [42]. Cement is chosen based on several factors, including the age-dependent compressive strength, fineness, heat of hydration, alkali content, tricalcium aluminate (C3A) content, tricalcium silicate (C3S) content, dicalcium silicate (C2S) content, and compatibility with admixtures. Regular hydraulic cement (OPC) is now widely used on construction sites. Differences in compound composition and fineness [43, 44] give different cement brands distinctive features in terms of how their strength develops and how they behave rheologically. Cement from a single source was chosen as a consequence. Regular hydraulic cement with the brand name RAMCO which complies with IS 1489(PT 1): 1991 was used in this study.

The Vicat needle penetration values are shown in Table 3. Thus, when the water quantity is 96 ml and the water consistency is 32 percent, the plunger settlement is 7 mm. The initial and ultimate setting time values are shown in Table 4.

Table 3: Consistency result of rutile impregnated cement mortar.

Percentage of water	Water quality (in ml)	Penetration value (in mm)
24	72	40
26	78	40
28	84	30
30	90	21
32	96	7

Table 4: Rutile-impregnated cement's initial and final setting times.

Properties	Values (minutes)
Initial setting time of cement mortar with TiO_2	85
Final setting time of cement mortar with TiO_2	420–580

2.11.2. Experimentation. Trials are conducted to determine the strength of both traditional rutile mortar and modified rutile mortar. The durability of mortar can be measured with a compressive strength test. TiO_2's response to cement mortar can be evaluated using two different tests: the stain removal test and the self-cleaning reaction test [38].

3. Results and Discussion

3.1. Compression Tests for Cubes. Standard and modified cement mortar cubes were tested for compressive strength at 7, 14, 21, and 28 days after application. A 70 mm-sized cube mold was utilized as the specimen for the mortar compression tests [41]. After drying the surface, every cube underwent testing.

The compressive strength of cement mortar after 7, 14, 21, and 28 days of curing is depicted in Figure 7. At 7 days, CM, M-1, M-2, and M-3 had respective strengths of 4.5 MPa, 4 MPa, 4.9 MPa, and 4.2 MPa. After 28 days of curing, the compressive strengths of CM, M-1, M-2, and M-3 are, respectively, 15.5 MPa, 14.8 MPa, 17.2 MPa, and 15.4 MPa. The M-3 mortar mix (5% rutile) gained the greatest strength among all other mixtures. The M-3 has a 10.96% higher strength than the CM (control mix).

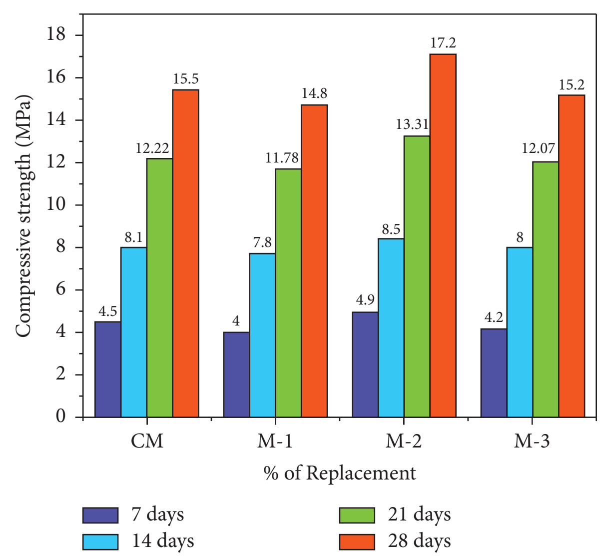
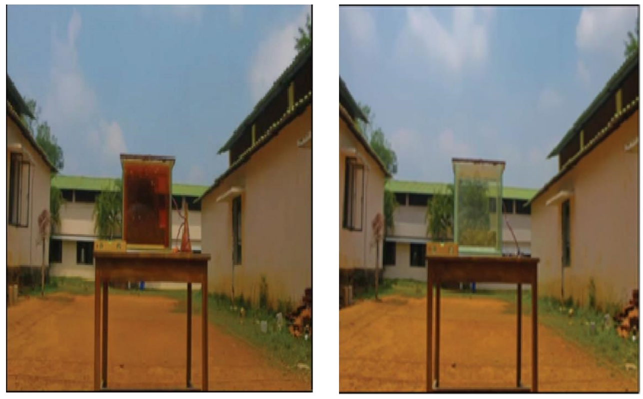


Figure 7: Resultant compressive strength of cement mortar for various mix designs for various curing days.

3.2. Stain Removal Test. The specimens were made by impregnating the surfaces of hardened cement mortar by applying 50 mg, 100 mg, or 150 mg of TiO_2 [24, 35, 45]. A control specimen was prepared without any TiO_2 impregnation. A specimen is allowed to dry in direct sunlight for thirty minutes. The surfaces are then sprayed with rhodamine B (RhB) solution [40] and exposed to sunlight for some time. Figures 5 and 6 depict the specimen's appearance immediately after the application of rhodamine dye and several hours later.

3.3. Self-Cleaning Reaction Test. The rutile mortar uses a photocatalytic technique to remove hazardous chemicals from the air, such as sulfur dioxide (SO_2) and nitrogen oxide (NO_2). Smog is formed on hot, bright days from a combination of nitrogen oxides and volatile organic compounds that can be removed using photocatalytic air cleaning to reduce harmful and irritating ozone levels [43]. When exposed to atmospheric moisture, nanoparticles of titanium dioxide absorb UV light and catalyze the production of reactive hydroxyl (OH) radicals. Most hazardous chemicals are oxidized and eliminated by these radicals [34, 46]. Tiny particles of titanic oxide catalyze the oxidation of adsorbed molecules when exposed to ultraviolet light with wavelengths shorter than 390 nanometers (above band gap actinic light). Particle size can vary from about 5 nm to about 50 nm. Figures 8(a) and 8(b) depict the specimen before and after the photocatalytic treatment.

The titanium dioxide particles form electron-hole pairs as a result of UV light absorption. When the electron is recombined with the exit, it travels to the particle surface, where it can react with hydroxyl (OH) ions from adsorbed surface water to form highly reactive hydroxyl radicals [40]. These radicals are formed when the hydroxyl (OH) group loses an electron. Air pollution molecules can be adsorbed onto TiO_2 particles, where they react with hydroxyl radicals that have also been adsorbed. If everything was perfect, byproducts of reactions would remain at the surface until they were fully oxidized. The goal of this study is to characterize the photocatalytic rates and reaction pathways for a range of VOC pollutants that contribute to smog formation. Even NOx and SOx, which are produced in industrial settings, can be catalyzed by TiO_2 nanoparticles.



(a) (b)

Figure 8: Before photocatalytic reaction (a) and after photocatalytic reaction (b).

3.4. Ultrasonic Velocity Test. Based on the relationship between wave velocity and mechanical characteristics, ultrasonic wave technologies have been widely researched for monitoring the setting and hardening processes of cementitious mortar and concrete materials [47].

The P-wave velocity distribution is shown in Figure 9 for the four different mortar types that were analyzed. P-wave velocities were found to be greater in the control mix mortars (those without the photocatalyst ingredient) [48]; this was to be expected given that cement-based mortars were used. It was discovered that increasing the amount of TiO_2 improved the velocity [19]. Mortars with 4 and 5% TiO_2 have higher velocities, whereas those with 6% TiO_2 have lower velocities.

It was discovered that the surface of hardened cement mortar containing 5% TiO_2 was extremely dense and had fewer pores as shown in Figure 10. The reason for this was obvious: the particles were stuck together. When compared to 0 percent, 4 percent, and 6 percent cement mortar specimens, the P-wave velocity of the 5 percent TiO_2 content specimen is high. Figure 11 depicts the EDS spectra of the 5% TiO_2 specimen. The concentrations of titanium, silicon (SiO_2), and aluminum were 33.42, 46.02, and 14.00%, respectively.

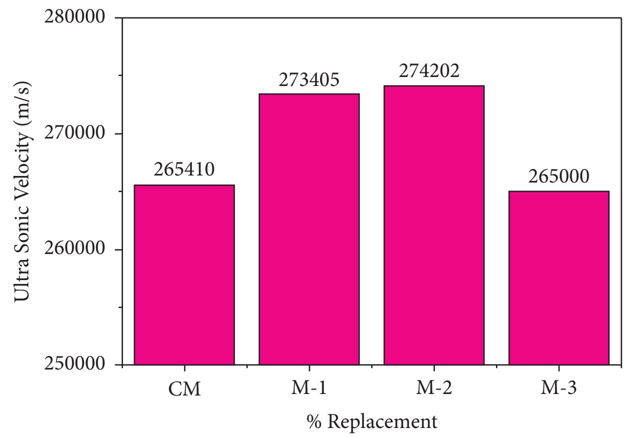


Figure 9: Ultrasonic velocity of specimens.

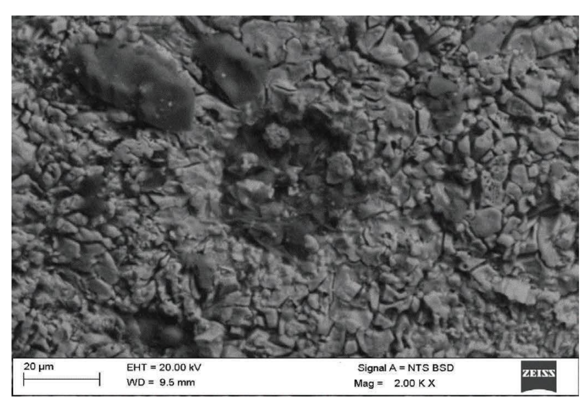


Figure 10: SEM image of 5% TiO_2 specimen.

3.5. Durability of TiO_2-Modified Cement Mortar. For up to 28 days, mortar cube samples were submerged in 5% sodium chloride and 5% magnesium sulfate solutions. After being submerged in the solution for 28 days, the samples were removed from the chemical solution and the mortar cubes' residual compressive strength was determined. Strength loss was calculated for specimens from each mix. Mortar cube specimens submerged for chemical resistance testing are depicted in Figure 12.

After being submerged in acid and sulfate for 28 days, the percentage of strength lost owing to attack is shown in Figure 12. CM lost 8.46% and 8.01% of its strength when exposed to acid and sulfate, respectively. The strength loss caused by acid and sulfate attack is rather moderate in mix M-2 compared to other mixes.

Titanium nanoparticles in the cementitious composite model the microstructure of the cement binder as a series of denser C-S-H phases. Additionally, it increases the composites' resistance to external physical and chemical impacts. Titanium nanoparticles segregated the total pore content and the pore contents of particular pore groups into few-harm pores (20–50 nm), detrimental pores (50–200 nm), and

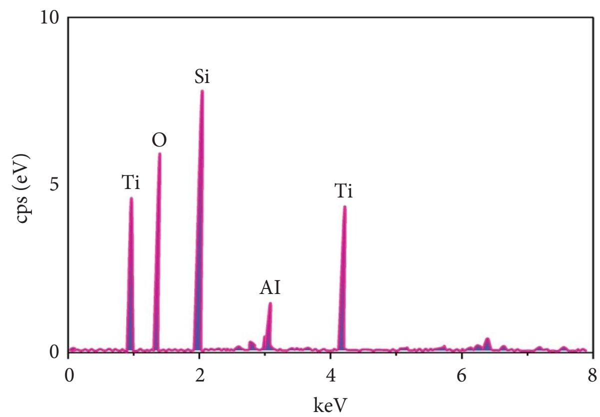


Figure 11: EDAX spectra of 5% TiO_2 specimen.

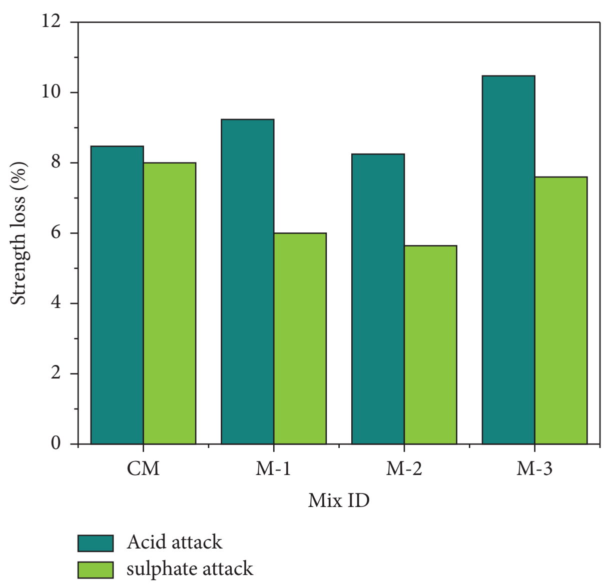


Figure 12: Strength loss due to acid and sulfate attack.

multiharm pores (>200 nm). This occurs as the hydration of the cement binder accelerates, resulting in a denser pore structure and increased microstructure compaction [20]. As a result of densifying the microstructure of the cement composite and decreasing the proportion of porosity in the total volume of cement binder [16, 49–52], materials with reduced water absorption and increased resistance to chloride, CO_2, and sulphates have been developed.

4. Conclusions

The present research idea demonstrates that the maximum photocatalytic efficiency was achieved with the impregnation of titanium dioxide under natural sunlight on cement mortar-hardened surfaces; the photocatalyst and natural sunlight were combined to provide a solution to environmental urban pollution. The compressive strength of the 5 percent powdered rutile phase impregnated with cement mortar (M-2) is greater than that of other mixtures, and the photocatalyst reaction efficiency is enhanced when rutile is present in high concentrations in the cement mortar. Compared to other mixtures, mix ID M-2 undergoes comparatively little potency loss due to acid and sulfate attacks. Consequently, the experimental findings of the current study demonstrate a simple and practical method for applying a photocatalyst with high photocatalytic efficiency, as well as its prospective application in the prevention of building facade pollution. From the SEM image of a 5% TiO_2 specimen, it was determined that the surface of hardened cement mortar containing 5% TiO_2 was extremely dense and comprised fewer fractures. With the aid of sunlight, atmospheric oxygen, and water present as humidity and precipitation, TiO_2 photocatalysis in cement provides an effective method for simultaneously achieving self-cleaning of building facades, a delay in the natural aging of surfaces, and a reduction in air pollution. Utilizing nanoparticles of titanium dioxide for photocatalytic air pollution reduction is technically feasible. Due to the vast air volumes that must be managed, it will be difficult to achieve this objective in a cost-effective manner.

Data Availability

The data used to support the findings of this study are included in the article.

Disclosure

The publication is only for the academic purpose of Addis Ababa Science and Technology University, Ethiopia.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Chandrasekaran Palanisamy (first author), Ganeshprabhu Parvathikumar (second author), S. Gnanasekaran (third author), and Samson Jerold Samuel Chelladurai (fourth author) wrote up the manuscript and conducted experiments. S. Sivananthan (fifth author), B. Adhavan, Geetha N. K. (sixth author), and Ramesh Arthanari (seventh author) supervised the experiment and wrote, structured, read, edited, and approved the final manuscript. Solomon Tibebu (eighth author) supervised the experiment and wrote, edited, and approved the final manuscript. All the authors made significant contributions to the document and agreed to its publication.

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