SMOG ABSORBING CONCRETE

Priyanka Gaikwad[1], Shamesh Rasal[2], Vinayak Desale[3], Saurabh Burud[4]

[1,2,3,4]*Dept. of Civil Engineering, NHITM College, Thane, Maharashtra, India*

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Abstract - Around *the globe one of the biggest collective concerns is that of pollution. In such conditions, a cementitious material that has pollution-eating and self-cleaning properties when applied to infrastructural work will be very beneficial and can contribute in cleaning the environment and help in improving sustainability*.

Key Words: photocatalysis, self cleaning concrete, TiO_2, activated carbon

1. INTRODUCTION

The cities are growing, traffic increasing, growth in trajectory, rapid growth in the economy, and industrialization with higher levels of energy consumption have resulted in an increase in pollution load in an urban environment (CPCB, 2010). Smog is air pollution, generally a mixture of fog and smoke in the air. Smog is a big problem in several countries and continues to harm the health of humans. Ground-level ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and carbon monoxide (CO) are especially harmful to old age people, children, and people with heart and lung conditions. To overcome this a construction material widely known as Smog Absorbing Concrete with the help of its photocatalytic ability can accelerate the natural oxidation process of many pollutants leading to an increase in their rate of decomposition and avoiding them from accumulating and forming persistent compounds. This cement has titanium dioxide (TiO_2) combined with other pozzolanic materials. This cement, when comes into contact with sunlight, triggers a chemical reaction, which results in the breaking down of some of the major pollutants' molecular formulas, which contribute to the formation of smog.

2. OBJECTIVE

The objective of this is to study the use of smog absorbing concrete in different structures. Also, the study of TiO_2 will reduce smog when it comes in contact with sunlight. To reduce harmful nitrogen oxides which are formed by vehicle combustion and other air pollution with the help of TiO_2.

3. LITERATURE REVIEW

Based on the results of chemical data, TiO_2 proves to be successful at removing a large amount of pollutants from the air [1]. TiO_2 is especially nano-sized, and is the most generally used component in photocatalysis structural materials thanks to its compatibility with conventional building materials, like cement, without deteriorating their performances [3].Titanium Dioxide could be a cementitious material that may replace cement in concrete to some extent. TiO_2 blended in concrete, helps to soak up pollution from the air, and concrete made is self-cleaning concrete so pollution adsorbed on the surface of the concrete within the style of powder is washed by water [4]. William Gregor discovered the element Titanium in 1791, in England. Between 1910 and 1915, the primary patents were issued for creating TiO_2. Fujishima and Honda found the photocatalytic splitting of water on TiO2 electrodes in 1972. When the titanium-containing ores are mined, they have to be converted into pure titanium dioxide. the 2 main production methods are the sulfate process and therefore the chloride process [7]. titania could be a white solid inorganic substance that's thermally stable, non-flammable, poorly international organization (UN) Globally Harmonized System of Classification and Labelling of Chemical (GHS) [9]. pigment (TiO_2) has been the semiconductor most utilized in photocatalytic paving thanks to properties like chemical stability and non-toxicity and high capacity to degradate organic and inorganic pollutants under UV-A (ultraviolet) radiation [10]. The effective mass approximation (EMA) becomes invalid when the electronic structure of TiO_2 departs from a band structure model (in this case, when at the nanoscale) [11]. titanium oxide has the very best average index of refraction known. For anatase, it is 2.55 and for rutile it's 2.76. These high values account for the exceptional light scattering ability of pigmentary oxide when dispersed in various media, which in turns yields the high reflectance and hiding power, related to this pigment [12].

A photocatalyst could be a compound that facilitates a chemical action upon absorption of sunshine and is generated within the process. The efficiency of the photochemical process could be a complex function of several factors like effective absorption of sunlight, quick charge separation after light adsorption to stop electron-hole recombination, product separation from the photocatalyst's surface, Compatibility between the redox potentials of the valence band hole and conduction band electron with those of the donor and acceptor species, respectively, &long-term stability of the photocatalyst [3]. the utilization of photocatalytic titania nanoparticles within the development of self-cleaning and de-polluting paints and microbiological surfaces is indicated. within the former case surface erosion and sensitized photooxidation is shown to be controlled by the utilization of catalytic grades of anatase nanoparticles, the general catalytic performance of titanic oxide particles has been found to be hooked into quite a number of parameters including the preparation method, annealing temperature, particle/crystal size, the particular area, the ratio between the anatase and rutile crystal phases, intensity level, and therefore the substrate to be degraded [12].

In the existence of UV radiations, $Ti0_2$ oxidizes the formation of micropollutants - NO_X, SO_X, NH_3, CO, toluene, benzene, ethylbenzene, and o-xylene. consistent with research, NO removal will be increased more effectively by combining hetero-catalyst with cement matrix

$$NO + OH^- \rightarrow NO_2 + H^+$$

NO_2 IS OXIDIZED AND NITRATE REMAINS ADSORBED:

$$NO_2 + OH^- \rightarrow NO_3^- (ADS) + H^+$$

If the absorbed nitrate isn't washed away for several days the surface will then get illuminated with sunlight and it'll undergo renoxification process. This process ends up in the formation of ozone. This process of ozone formation is given below:

$TiO_2 + HN \rightarrow H_{VB}^+ + E^-_{CB}$

$O_2 + E_{CB}^- \rightarrow O_2^{\bullet -}$

$NO_3^- + H_{VB}^+ \rightarrow NO_3^{\bullet}$

$NO3 + HN \rightarrow NO2 + O^{\bullet}$

$NO_3^{\bullet} + HN \rightarrow NO + O_2$

$O^{\bullet} + O_2 + M \rightarrow O_3 + M$

this is one of the major problems despite so many benefits and to overcome this materials like modified TiO_2, Pt and Ni-doped TiO_2 nanoparticles can be used [2]. HNO_3 reacts with NO owing to the action of TiO_2 photocatalysis in the purifying process. The reaction result is that HNO_3 must be oxidized to NO_3, The possible reactions are considered as follows.:

$HNO_3 + h^+ \rightarrow NO_3 + H^+$

$HNO_3 + O^-_5 \rightarrow NO_3 + OH^-_{ads}$

$NO_3^- + h^+ \rightarrow NO_3$

$NO_3 + O_5^- \rightarrow NO_3 + O_5^{2-}$

$NO_3 + NO \rightarrow 2NO_2$ [8].

This process of ozone formation is given as: aning is a favorable property in terms of contamination-free surfaces. Among the many materials with superhydrophilic properties, TiO_2 is one in every of the foremost promising due to its favorable physical and chemical properties. TiO_2 can exhibit both photocatalytic and photo-induced superhydrophilicity properties. Superhydrophilicity is of great importance to civil structures since it might prolong the aesthetic durability of the structures [3]. Additionally to removing pollutants, it also removes biofilm due to reaction with UV light, the TiO_2 surface can remove biological substances including E. coli, Staphylococcus aureus, staph, SARS, and MS2 coliphage [1]. self-cleaning this many be described in an exceedingly number of formats. For coatings and cementitious coated materials this could imply a surface which under light activation would have the power to continuously destroy or "burn-off" by oxidation the surface dirt layers whether or not they be, carbonaceous, oil or soil. This may be seen visually in a number of the commercial trials undertaken by Millennium Chemicals in tunnels in Italy (in conjunction with Global Engineering, Milano). The photocatalytic activity of eco-coatings may be measured by as an example, determining the fading rate of an impregnated dye such as Methylene Blue [12].

Activated Carbon, AC, made from powdered coconut shell was mechanically shredded of less than 70 μm. Sodium dodecyl sulfate (SDS) was obtained from Yuanye Biotechnology, Ltd., Shanghai. All other chemicals were of analytical grade, and doubly refined and deionized water was used throughout the experiment. AC is mixed with the TiO2 to adsorb any remaining NO_2 from its surface. Accordingly, both NO and NO_2 can be effectively filtered by TiO_2 and AC [8].

Two of the most important and effective applications are in roofing tiles and structural concrete, both of which are absolutely essential in construction [1]. Photocatalytic self-cleaning concrete is already used for: concrete paver blocks, sound barriers and facade elements, precast architectural concrete panels, pavements, sidewalks, finish coat applications, roof tiles, cement-based tiles and cement-based restoration products [6].

10 nm TiO_2 would lead to further enhancement in the compressive strength of the cement composite rather than 15 nm TiO_2 [3]. The compressive strength has been increased by the 1% replacement of cement by TiO_2 and further strength decreases on the increment of TiO_2. TiO_2 used in this experimental work is anatase base having particles size 20-25μm. Further study can be extended on various properties of concrete by changing the particles size of titanium dioxide and various grade of concrete [7].

4. METHODOLOGY

4.1 Materials

Ordinary Portland cement (53-grade), Fine Aggregate (River Sand), Coarse Aggregate (10-20 mm), Water, Titanium Dioxide (50 micron, 99.5% purity) and Activated Carbon (50 micron, 99.5% purity).

4.2 Method

Firstly we cast the concrete cube of 150 x 150 x 150 mm dimensions with M35 grade

Concrete blocks

In the concrete block, we will replace cement with titanium dioxide and activated carbon with 0.5%, 1%, and 1.5 %. After the casting we will check the strength of the sample by compression test for 7, 14, and 28 days After that we will keep the sample in the chamber for smog absorbing test Chamber will be 40x30x30 cm with two holes one will be connected to the source of the smog (which can be a vehicle or any other source) and other will be connected to the gas analyzer or PUC for measuring the absorbed gas.

5. EXPERIMENTAL WORK

5.1 Compression Test

Compressive strength is the capability of a material or construction structure to carry the forces on its surface without any crack or deflection. A material under compression tends to reduce the size elongation, while in tension, the size of the material.

Compression Testing Machine

5.2 Smog Absorbing Test

We are using PUC (Pollution Under Control Machine) in the smog absorbing test to determine the presented gas like CO_2, CO, and NO_2 in the smog and the amount of absorbed gas by the titanium dioxide and activated carbon. It is used to analyze and assist in areas such as process safety enhancement, quality studies, efficiency analysis, and emissions recording.

6. RESULTS

Compression Test

The concrete cube is tested by a compression testing machine after 7 days of curing, 14 days & 28 days of curing. Force should be applied gently at the rate of 140 kg/cm^2 per minute till the Specimens fails. Force at the failure divided by the area of the concrete cube gives the compressive strength of concrete.

Table 1 - 7 Days Compression Test

Sr. No.	**Mix**	**Peak Load (KN)**	**Compressive Strength (N/mm^2)**
1	Regular M35	591.03	26.27
2	0.5 % TiO_2 & 0.5% AC Replaced with cement	691.2	30.72
3	1.0 % TiO_2 & 1.0% AC Replaced with cement	716.6	31.85
4	1.5 % TiO_2 & 1.5% AC Replaced with cement	607.1	26.98

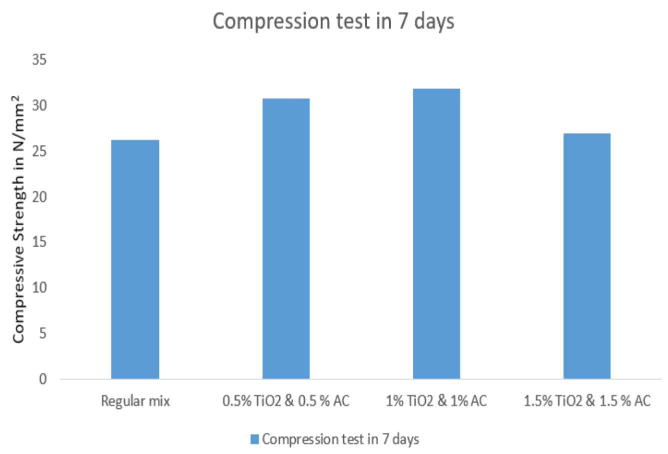

Chart – 1: 7 Days Compression Test

Table 2 - 14 Days Compression Test

Sr. No.	Mix	Peak Load (KN)	Compressive Strength (N/mm²)
1	Regular M35	685.2	30.45
2	0.5 % TiO_2 & 0.5% AC Replaced with cement	799.4	35.53
3	1.0 % TiO_2 & 1.0% AC Replaced with cement	837.6	37.23
4	1.5 % TiO_2 & 1.5% AC Replaced with cement	719.9	32.00

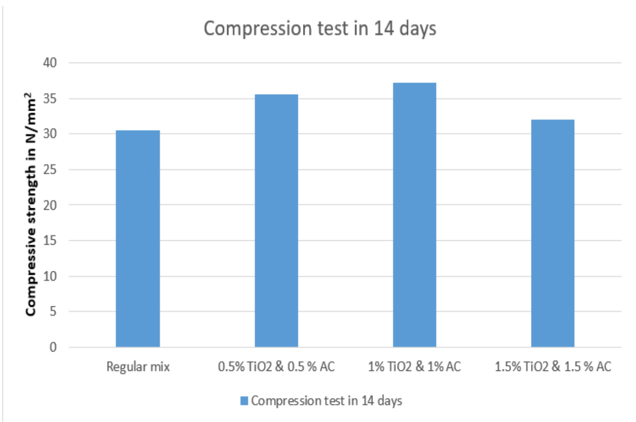

Chart – 2: 14 Days Compression Test

Table 3 - 28 Days Compression Test

Sr. No.	Mix	Peak Load (KN)	Compressive Strength (N/mm²)
1	Regular M35	807.8	35.91
2	0.5 % TiO_2 & 0.5% AC Replaced with cement	949.6	42.20
3	1.0 % TiO_2 & 1.0% AC Replaced with cement	987.8	43.90
4	1.5 % TiO_2 & 1.5% AC Replaced with cement	846.9	37.64

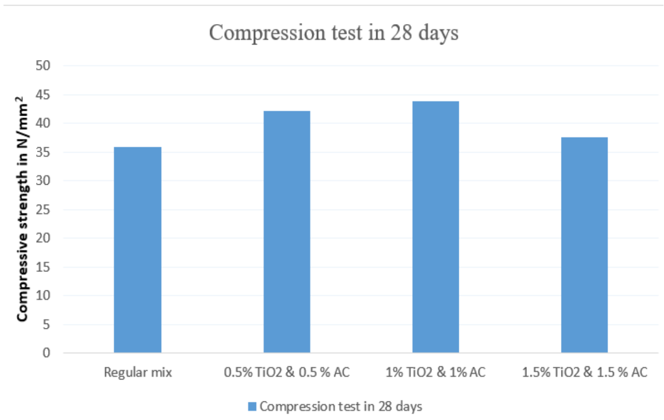

Chart – 3: 28 Days Compression Test

7. CONCLUSION

1. As TiO_2 is a cementitious nanomaterial so there is no change in the compressive strength of concrete. & We are able to use TiO_2 as an admixture also up to a specific limit.

2. The percentage replacement of TiO_2 & AC in concrete shall be between 0.5% to 1%, which is the most economical and most helpful.

3. The study framed that the TiO2 & AC reduced the harmful pollutants from the air like NO_X, HC, and CO_X.

4. AC helps to extend the speed of absorption.

5. As TiO_2 applies to structures with paint so it might be quite expensive but it reduces pollutants which saves thousands of lives. Also, we will use a photocatalyst sheet of TiO_2 as a replacement for paint.

6. We will use TiO_2 & AC not only on buildings but we are able to apply it on the surface of roads or we are able to mix TiO_2 & AC with concrete by this way also it is effective to cut back smog.

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