International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 07 | July 2020 www.irjet.net p-ISSN: 2395-0072

Use of Smog Absorbing Concrete in Road Construction

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Abstract - *The purpose of this paper is to solve the ever-increasing pollution problem in today's world, a sustainable solution is needed. This sustainability includes environmental protection, as well as social and economic equity. To achieve a fully sustainable solution, all three of these critical issues must be solved. The most promising solution to this problem is titanium dioxide-blended concrete. The material has similar structural properties to normal concrete, but because of the titanium dioxide, can remove pollutants from the air by decomposing them into harmless compounds. This solution provides a viable option to urban areas, where pollution levels are generally higher, due to the large potential surface area for the material.*

***Key Words*: Smog absorbing concrete1, Titanium dioxide2, Photo catalytic process3, Smog adsorbing test4.**

1. INTRODUCTION

Ever since the starting of the Industrial Revolution, the entirety of the planet has battled the by-products of increased productivity: pollution. Since the mid-1800s, pollution levels have increased at a rapid rate. More recently, pollution has been monitored worldwide by the United Nations. In more recent years, pollution has decreased slightly, but continues to pose massive problems due to high concentrations. Due to this, the World Health Organization (WHO) set maximum acceptable values of common pollutants. Particle matter was limited to between 10 and 20 µg/m3, depending on size, nitrogen oxides to 40 µg/m3, sulphur dioxide to 20 µg/m3, and ozone to 100 µg/m3. These pollutants all contribute to the build-up of smog.

Currently, the WHO states that 92% of the world's population live in areas where at least one of the air quality standards are not met. As a result, many people directly and indirectly suffer the consequences of industrialization, particularly poor people due to housing conditions near polluted areas. The WHO estimates 88% of those affected by health problems due to pollution are poverty-stricken, with a majority from Southeast Asia. Adverse health effects result from high quantities of pollutants in the air, ranging from minor problems such as chest pain, coughing, reduced resistance to infections, and fatigue, to more serious problems such as acute bronchitis, aggravated asthma, and development of chronic respiratory illnesses, irregular heartbeat and premature death. Overall, 3 million deaths occur annually due to pollution, with two thirds of deaths caused by heart disease and stroke.

2. Literature Review

Research shows that all concretes have some tendency to absorb NO2. However, this tendency depends on the concrete mix design, and it is also reduced significantly over time by carbonation. The use of small additions of activated carbon can greatly enhance the NO2 absorption properties of many classes of concrete and also reduces the negative influence of carbonation the process.

The use of "smog-eating concrete" may provide a way to improve our cities. By reducing ambient NOx concentrations, it will have a benefic impact on human health as well as on animal and plant life.

3. Objectives of paper

- To study smog eating concrete.
- To check performance of smog eating concrete for pollution control.
- To reduce harmful nitrogen oxides which are formed by vehicle combustion.
- To check performance of smog eating concrete for pollution control

4. Research Methodology

4. 1. Titanium dioxide:

Titanium dioxide, also known as titanium (IV) oxide or titania, is the naturally occurring oxide of titanium, chemical formula TiO2. When used as a pigment, it is called titanium white, Pigment White 6 (PW6), or CI 77891. Generally, it is sourced from limonite, rutile and anatase. It has a wide range of applications, including paint, sunscreen and food coloring.

Titanium dioxide is cementations material which can replace cement in concrete for some extent. As titanium dioxide blended in concrete, it helps concrete to adsorb pollution from air and concrete made is self-cleaning concrete so pollution adsorbed on surface of concrete in the form of powder can be washed by water. Titanium dioxide accelerate the reaction of conversion of harmful pollutants in harmless pollutants.

Fig -1: Titanium dioxide

4.2 Photo Catalytic Process

This property allows for the oxidation of various molecules, including the pollutants in the air and on the surface, as well as the formation of hydroxyl and oxygen radicals from water and oxygen in the air. The products of these reactions then form salts. The salts are then washed off of the surface efficiently due to the super-hydrophilicity of titanium dioxide. When water normally encounters a surface, it tends to bead up due to the combination of the surface tension of the water and the difference in polarity between the water and the surface. Since both water and titanium dioxide are polar, they tend to be attracted to each other. This attraction is strong enough to compensate for the water tension, and as a result, water will run as a sheet rather than droplets across the surface, allowing for a more complete wetting of the surface.

In addition to removing pollutants, the surface also proves effective at removing bio-film. Because of the reaction to UV light, the titanium dioxide surface can remove biological substances including E. coli, Staphylococcus aureus, staph, SARS, and MS2 coliphage. Tests show that the titanium dioxide concrete can remove nearly 100% of a sample within an hour.

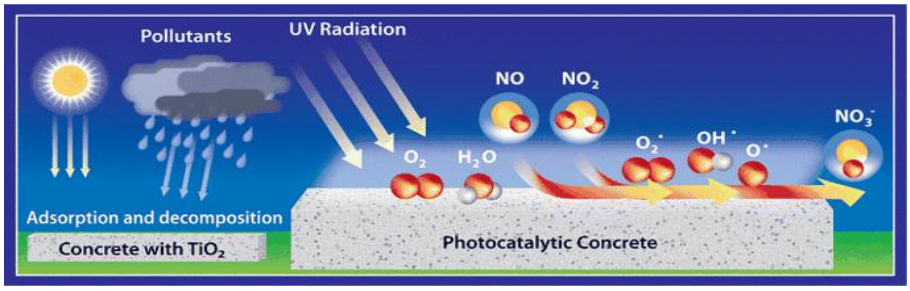

Fig -2 Photo catalytic process

4.3 Reactions with Pollutants

A large source of pollution in the air is nitrogen oxides (NOx), which are harmful to the environment by themselves and also can react with oxygen in the air to form ozone, the main component in smog. According to Laurent Barcelo's paper, titanium dioxide is not consumed when used as a photo catalyst, meaning that it can be used in the process without needing to be constantly

replaced. In order to remove nitrogen oxides entirely, a multi-step process is needed. The process, according to the Czestochowa paper, starts with the reaction

$NO + 2OH^- \longrightarrow NO_2 + H_2O.$

This process alone does not remove nitrogen oxides but rather converts nitrogen monoxide to another harmful compound, nitrogen dioxide, which allows a second reaction to occur:

$NO_2 + OH^- \longrightarrow NO_3^- + H^+.$

This reaction actually removes the remaining nitrogen dioxide and converts it to nitrate ions, which then form nitric acid, HNO_3, with the ionized hydrogen. When the reaction takes place on or near concrete, grout (present in some types of concrete) can react with this nitric acid and form a neutral ionic salt. Thus, harmful nitrogen oxides are transformed into harmless molecules. Though this can happen without the presence of titanium dioxide, the photo catalytic properties of the compound are very important for improving the efficiency and effectiveness of this reaction.

4.4 The mix proportion for M30

Cement	Sand	Course aggregate	Water
394	819.22	1047.30	197
1	2.07	2.65	0.55

Table -1 Mix Proportion for M30

4.5 Mix Proportion

The mix proportions are finalized for various percentage of replacement of mineral admixtures.

Mix	Materials		Cement (kg/m^3)	TiO_2 (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Water (kg/m3)	w/c
	Cement %	TiO_2%						
NM	100	-	394.00	-	819.22	1047.30	197	0.55
SAC1	99	1	390.06	3.94	819.22	1047.30	197	0.55
SAC2	98	2	386.12	7.88	819.22	1047.30	197	0.55
SAC3	97	3	382.18	11.82	819.22	1047.30	197	0.55
SAC4	96	4	378.24	15.76	819.22	1047.30	197	0.55
SAC5	95	5	374.30	19.70	819.22	1047.30	197	0.55

Table -1: Mix proportions for M30, cement replacement by TITANIUM DIOXIDE

4.6 Smog adsorbing test on concrete block

Apparatus: Two wheeler, glass chamber having two hole for inlet and outlet, concrete and mortar cubes, two pipes, multi gas analyser.

Setup:
1. Prepared a glass chamber having size 40cm x 30cm x 30cm with two holes on cover of chamber.
2. From one hole we were supplying polluted air through the silencer of petrol engine vehicle.
3. Second hole was for the checking quality of air passing over the concrete block with the help of multi-gas-analyser machine's probe.
4. Multi-gas-analyser has a facility of providing the quantity of different pollutant.
5. The pollutants checked by the multi-gas-analyser are , CO, CO_2, HC (hydrocarbons).

Fig -3 Smog Absorbing Test

5. Result & Analysis

5.1 Compressive strength of M30 concrete cubes are:

For 14 days and 28 days

Mix	TiO2	14 Days	28 Days
NM	0%	20.05 KN	30.4 KN
SAC 1	1%	19.63 KN	30.56 KN
SAC 2	2%	19.34 KN	33.57 KN
SAC 3	3%	17.30 KN	29.55 KN
SAC 4	4%	16.75 KN	28 KN
SAC 5	5%	15.73 KN	26.94 KN

5.2 Smog adsorbing test on concrete block

Concrete	CO2	HC
0% TiO2	2.51%	951 ppm
1% TiO2	2.40%	862 ppm
2% TiO2	2.38%	804ppm
3% TiO2	2.30%	760 ppm
4% TiO2	2.22%	714ppm
5% TiO2	2.12%	661ppm

5.3 Strength of Concrete Vs TiO2% Graph

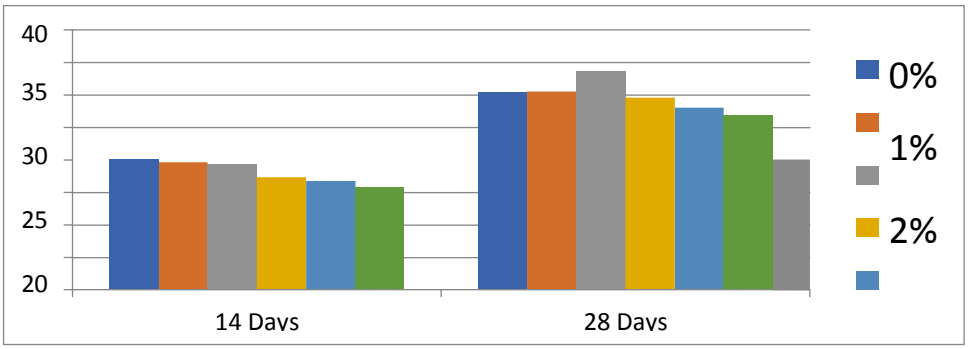

Chart -1: Comparison of strength of concrete vs Strength after replacement of TIO2

5.4 Smog absorbing concrete Vs TiO2% Graph

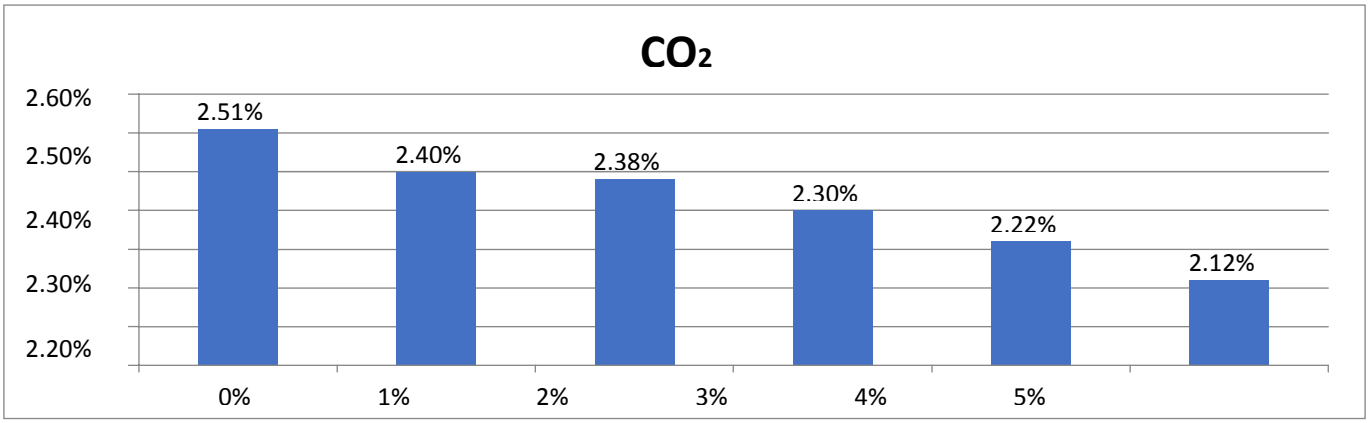

Chart -2: CO2 removal for % of TIO2 replacement

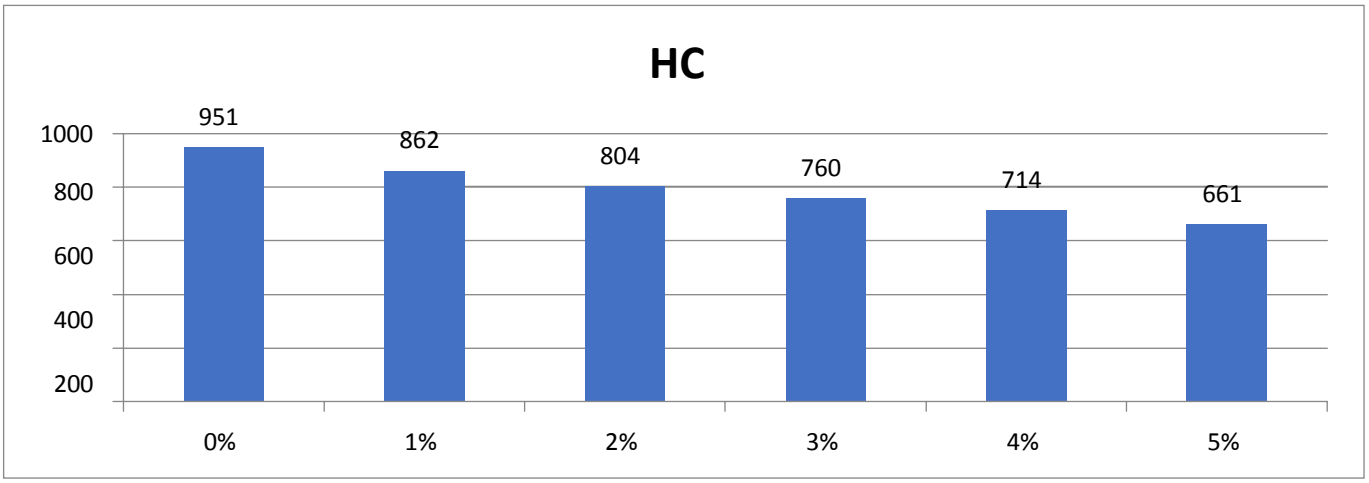

Chart -3: HC removal for % of TIO2 replacement

6. CONCLUSIONS

- The study framed that the effect of Concrete made by replacing cement by TiO2 is very effective to reduce harmful pollutants such as COX, HC, particulate matter etc.
- As TiO2 is cementitious nano material so there is no any change in compressive strength of concrete.
- This photocatalytic concrete is quite expensive but it reduces more pollution which can save thounsads of life.
- The percentage replacement of TiO2 in concrete shall be in between 2% to 3%, at which it is most economical and most helpful to reduce harmful pollutants such as HC and CO2.

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