Photocatalytic Self cleaning Concrete

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Abstract--- Air pollution is an environmental problem that has significant negative health implications for humans as well as other living organisms. Major primary pollutants that are produced by human activity include nitrogen oxides (NOx), sulphur dioxide and volatile organic compounds (VOCs) which are emitted from combustion at high temperatures. When photocatalytic materials absorb ultraviolet radiations from the sun, hydroxyl radicals and superoxide anions are created that have the ability to react with pollutant molecules such as NOx, SOx, thus converting to less harmful substances. In this paper properties of concrete such as Grade of concrete is M25, W/C ratio is 0.45, Tio_2+OPC=3.5:96.5 has been taken.After one day of curing all samples were coated with RhB (Rhodomine dye) solution on top side and oobservations of the reduce the dye is measured between different time intervals.

Keyword: Concrete, Water/cement ratio, Tio_2, Rhodamine dye.

I. INTRODUCTION

Photocatalytic materials (TiO_2) are a technology that could help mitigate air pollution and ultraviolet rays. Photocatalytic components use energy from sunlight (or other ultraviolet light sources) and convert into harmless substances. These products reduce NOx, SOx, tobacco smoke, Bacteria etc.,from the atmosphere and also serve as self-clean material. Photo catalytic concrete was used more in architectural and civil engineering projects in Japan as a self-cleaning material.

Photocatalytic materials are help to mitigate air pollution directly. When photocatalytic materials absorb ultraviolet radiation from the sun, hydroxyl radicals and superoxide anions are created that have the ability to react with pollutant molecules such as NOx to convert them to other, less harmful substances. This could be particularly advantageous in areas with high levels of air pollution. Several studies have found that the most efficient photocatalytic material for removing NOx and VOCs is titanium dioxide (TiO2) in anatase phase. Significant research has been conducted on TiO2 incorporated into photocatalytic coatings for concrete specimens and incorporated directly into concrete, although few studies have been published that thoroughly test commercially available coatings.

The photocatalyst, titanium dioxide (TiO2), is a naturally occurring compound that can decompose gaseous pollutants with the presence of sunlight. Applying TiO2 to pavement of road it can help to remove emission pollutants right next to the source, near the vehicles that drive on the pavement itself.

II. HISTORICAL BACKGROUND

In 1970s, it was discovered that titanium oxide activated by light illumination decomposes water by electrolysis. This phenomenon was known as the "Honda-Fuj is hi ma Effect". Based on this discovery, the products such as titanium oxide coating films, composite material etc. have been developed and applied to water purification, antifouling protection and so on Photocatalysis of cement-based materials is a recent matter. First developments were made by Italcementi - Mitsubishi and several patents have been filed to date (16 of them by Italcementi), with a progressive development of new products that are commercially available Photocatalysis was firstly applied to building materials to obtain self-cleaning and antibacterial surfaces and had its best moment in Japan in the 1990s. Just in Japan, numerous scientific conferences and national expositions were organized on this innovative topic considering titanium dioxide as the most common catalyst. The first official publication on such products was presented by L. Cassar et al. in 1997 [1]. Since then, the development of photocatalytic cements has been carried out with increasing innovative solutions, passing from the self-cleaning performance to depolluting effect. Photocatalytic Self-cleaning concrete has been used on buildings such as Rome’s church “Dives in Misericordia”(Fig.1)

Fig. 1: Church “Dives in Misericordia”

III. PRINCIPAL BEHIND SELF CLEANING CONCRETE

Titanium dioxide is a naturally occurring compound and is used in toothpaste, sunscreen, paint, plastics, cosmetics, and other products. Because it is white, harmless, and inexpensive, TiO2 powders were used for white pigments in ancient times (Hashimoto, Irie, & Fujishima, 2005) [2]. It is used in sunscreen because it can absorb UV light. In the sunlight, TiO2 is activated by ultraviolet (UV) radiation ($\lambda <$ 390 nm) to oxidize air pollutants, such as nitrogen oxides (NOx) and volatile organic compounds (VOCs), into other inorganic compounds. In a photocatalytic reaction with TiO2, no chemical reactants are used. The TiO2 does not get consumed in the reaction; so it can theoretically be used indefinitely. TiO2 photocatalysis can be performed even in weak UV light (Hashimoto et al., 2005) [2] . TiO2 has a wide band gap, thus only ultraviolet light with a wavelength below 387 nm is absorbed (Fernandez-Rodriguez et al., n.d.; Hong et al., 2005) [3]. Photocatalysts activated by UV lights will decompose organic materials like dirt (soot, grime, oil, and particulates), biological organisms (mold, algae, bacteria, and allergens), airborne pollutants (VOC, tobacco smoke, NOx, and SOx), and chemicals that cause odors .

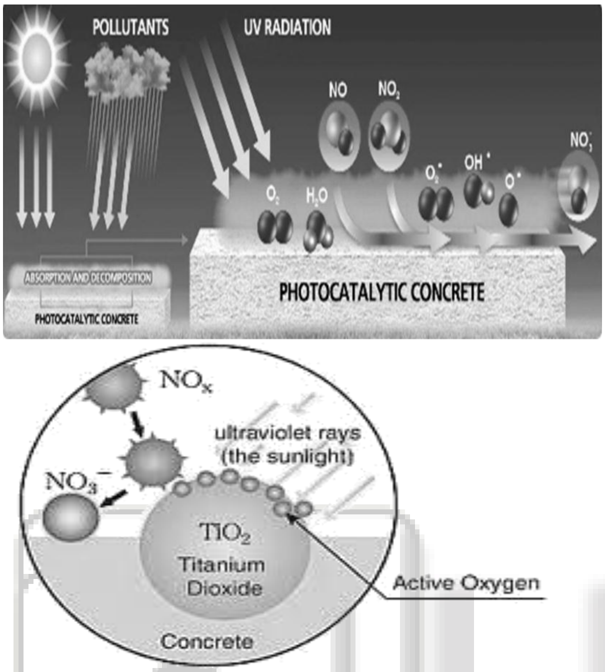

Fig. 2: Process between concrete pavement and UV rays and other oxide [4]

Most inorganic pollutants, like rust stains, are not catalyzed. After they have been catalyzed, the materials break down into oxygen, carbon dioxide, water, sulfate, nitrate, and other inorganic molecules. There are many commercial products that use photocatalytic reactions to make them as self-cleaning materials. Some successful examples are glasses, tiles, and concrete (Puzenat, 2009) [5]. Titanium dioxide is also used in concrete for buildings and ceramics for tiles, but only the part at the surface can be activated (Puzenat, 2009) [5]. These products can self-clean and reduce NOx in the atmosphere.

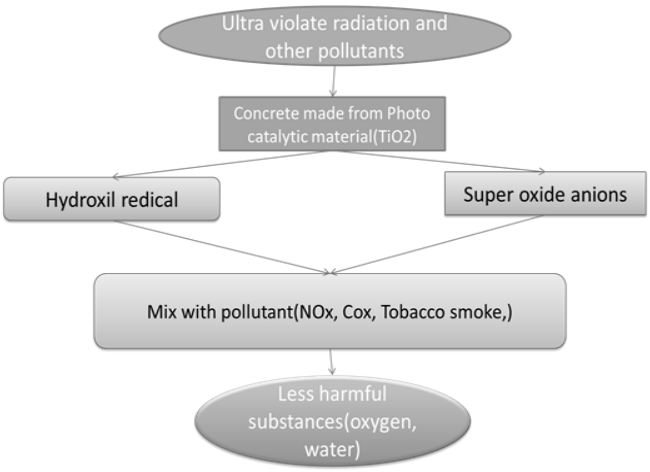

Fig. 3 Photocatalytic process

IV. AN EXPERIMENTAL PROGRAM

A. Materials

Materials used in the developing cement slurry have the following properties:

- Cement: Ordinary Portland cement of 53 grades with Specific Gravity 3.15, available in local market.
- Fine aggregate [FA]: Fine aggregate (river sand) obtained from local market was used in this study conforming to the Indian standard. (Zone-II). Specific gravity of Fine aggregate was 2.68.
- Coarse Aggregate [CA]: Coarse aggregate obtained from Local market (Sayla/sevaliya) was used in this study conforming to Indian standards. Specific gravity of coarse aggregate was 2.84.
- Water: Potable water was used for mixing.

B. Mix design of self-cleaning concrete:-

Two sets of photocatalytic cement pastes were prepared, one for each of the two commercial TiO2 products. The TiO2 and white PPC were dry mixed in the mass ratio 3.5:96.5. 20g of the mixture was subsequently hydrated with 8g of distilled water (water : solid mixture ratio, w/s = 0.4). A third set (control) was prepared without photocatalyst. After mixing, pastes were cast in 42 mm diameter x 5 mm height moulds and let harden (with no cover) for one day at room temperature and 80.5 % relative humidity. Six cement discs were produced for each set. After one day of curing, all samples were coated with RhB solution. The coating area was approximately 1.2 cm^2. All three sets were subsequently irradiated with a UV lamp and reflectance measurements were performed after various time intervals using a StellarNet EPP2000 Spectrometer.

Present study involved M-25 grade of concrete with W/C ratio 0.45 (A.M.Neville). Consider Table 1 for Mix Design. The table represents the value of 6 cubes.

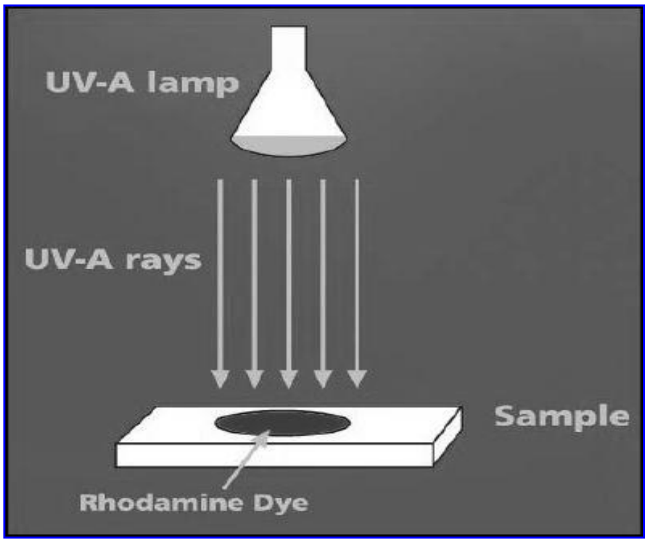

Fig. 3: Self – cleaning Measurement [10]

Cement (Kg/m^3)	FA (Kg/m^3)	CA(Kg/m^3)		Water (Kg/m^3)	Tio_2: Cement
8.07	13.53	14.13	10.22	3.76	3.5 : 96.5

Table 1: Mix design proportions

C. Casting and Measurement:-

Remove moisture from fine and coarse aggregate and mix it for 1min in concrete mixture, then add 1/3 part of water and mix for 30sec. Further add Mix of TiO_2 and cement then mix for 30sec then add remaining water again and mix for 3min. Then vibrate for 3min and put in slab, beam, and cube and make the surface smooth. All concrete batches were prepared in rotating drum mixture. First, the aggregates (Fine aggregates and coarse aggregates) are introduced in the mixture and then one- half of the mixing water is added and mixture machine is rotated for approximate two minutes and next cement is introduced with Tio_2.150 mm × 150 mm × 150 mm concrete cubes are cast to see the photocatalystic effect(Fig.3). After one day of curing, all samples were coated with RhB (Rhodamine dye) solution on top side.Observation of reduce the dye is measured between different intervals. Cubes were put against the sun light.

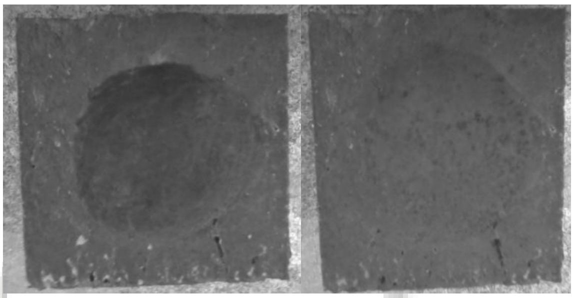

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Fig. 4: Casted specimen with RhB

V. RESULT

- From the above experimennt we can conclude that the effect of Rhodamine dye is decreases between different time interval.
- Reduced levels of several environmental pollutants. NOx, SOx, VOC's etc.
- Continuous oxidizing action results in a clean building for the life time of the structure.
- More environment friendly (no chemical cleanings).
- Lower lifecycle maintenance costs.
- Potential for Innovation in Design LEED point credits for using the technology:-
  1.Exceptional performance in aged reflectance.
  2. Exceptional performance in pollution abatement

VI. CONCLUSION

- Research into photocatalytic technology has been progressing for over three decades.
- Photocatalytic technology will continue to improve with time and development becoming more efficient and effective.
- Photocatalytic concrete offers building professionals a unique opportunity to contribute to sustainable development goals while potentially improving the value of their investment.

VII. REFERENCES

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