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An Experimental Review on air Purification and Self Cleaning by Incorporating Titanium Dioxide in Concrete Pavement

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Abstract: ***The research is focused on the efforts made to reduce air pollution by using photocatalytic material. In Indian context the dilemma of air pollution is augmented in preceding two decades, of which, our capital city Delhi is the perfect paradigm. This research is performed to cease air pollution in regional context i.e. Nashik, Maharashtra, India. Upto certain extent the air quality of Nashik is still acceptable, but in near future prospect it will degrade due to hasty escalation in industrialization, deforestation, population, etc. To recuperate this ambient air quality of Nashik it is obligatory to adopt innovative techniques and materials, such as Titanium Dioxide. Titanium Dioxide (TiO2) is a naturally occurring photocatalytic material; it acts as a catalytic material to speed up the oxidization process. We are studying effectiveness of photocatalytic concrete, with respect to Oxides of Nitrogen (NOx), because significant pollutant of Nashik is Ozone. Presence of NOx in air contributes to the formation and modification of other air pollutants, such as Ozone, Particulate Matter and to Acid Rain.***

Keywords: Photocatalytic, Titanium Dioxide, Oxidization, Oxides of Nitrogen, Ozone, Particulate Matter, Acid Rain.

I. INTRODUCTION

The aim of this project is to use of photocataliytic concrete in order to reduce the air pollution from the atmosphere. Several methods are introduced since last three to four decades but the rate of pollution is increasing day by day. The rapid population growth and economic development in country are degrading the environment through the uncontrolled growth of urbanization and industrialization. One of the major causes of environmental degradation in India could be attributed to rapid growth of population, which is adversely affecting the natural resources and environment. The growing population and the environmental deterioration face the challenge of sustained development without environmental damage. Due to increase in population and lifestyle standards, the use of vehicles such cars, bikes and trucks, containers, diesel engine equipment's in industries, are much larger than rural area. In India, big metropolitan cities like Delhi, Mumbai, Chennai and Calcutta are facing problems due to air pollution from vehicular and industrial emissions. These emissions at local level contribute to the global environmental problems.

The concept of this paper is based on self-cleaning concrete which exhibits air purifying properties. Under the action of sunlight, a catalyst present on the surface of the material is activated, enabling degradation of pollutants from the surroundings and transformation to less harmful products. It is a promising technique to reduce a number of air contaminants, especially at sites with a high level of pollution. We have provided a porous layer of photocalytic concrete on top and a conventional concrete layer at the bottom.

The worst thing about vehicular pollution is that it cannot be avoided as the pollutants are emitted at the ground level where we breathe. Pollution from vehicles gets reflected in increased mortality and morbidity and is revealed through symptoms like cough, headache, breathing disorders, nausea, irritation of eyes, various bronchial problems and visibility. The pollution from vehicles are due to discharges like CO, unburned HC, NOx, soot, suspended particulate matter (SPM) and aldehydes, etc. A recent study reports states that in Delhi one out of every 10 school children suffers from asthma that is caused due to vehicular pollution. The amount of vehicles depends upon population of city. As population increases, the use of vehicles, industries, burning of fuels, etc. increases. This causes air pollution.

Nashik is rapidly growing city of India and 16th most developing city in the world. The population of Nashik is increasing rapidly from three decades (i.e. from 1981). According to MPCB reports Air Quality Index of Nashik is satisfactory. The population growth rate of Nashik is very high. . The ambient air quality is very important for any city's growth as well as health. To prevent the air pollution we must take strong designs. Modern methods should be adopted to reduce pollution and to protect the future.

II. METHOD

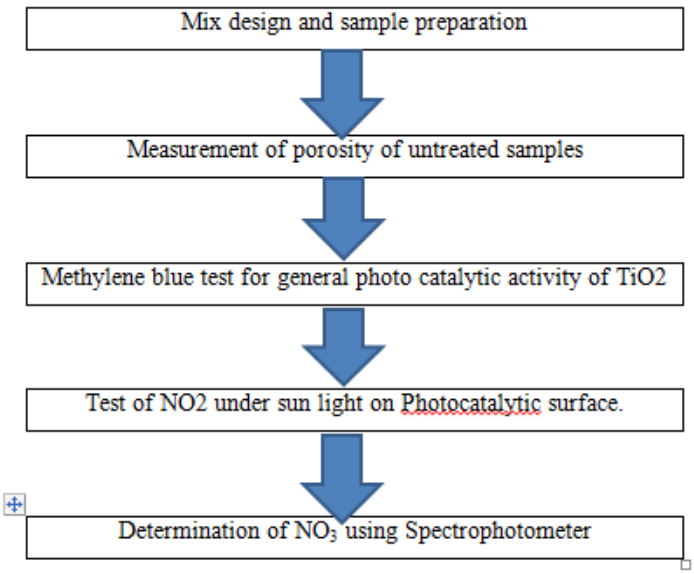

Fig.1. Flow Chart of methodology

Mix design and sample preparation:

The pavement block was divided in two parts that is upper layer with TiO2 and bottom layer without TiO2. The bottom layer was of M35 grade which is suitable for Light traffic (IS 15658-2006).Upper layer was prepared for air purification process. This was consisting of pervious concrete. The aim was to achieve maximum strength with moderate porosity. The bottom layer was of conventional paver block to achieve maximum density and strength. For upper layer various trail samples were prepared. The trail sample size was (6.5 x 6.5 x 6.5) centimeter. The fine aggregate used 6.7mm, 4.75mm, 2.36mm and 1.18mmin various ratios. The aggregates were properly sieved. Ordinary Portland cement was used with water cement ratio of 0.4. The samples were hand mixed. The samples were left for 28 days curing. Then the samples were tested under CTM. The trail samples of upper layer selected on the basis of their strength. The aggregate proportions were divided in two parts. The bottom layers of all samples were same. Final samples were casted in actual size of the paver block. The size of block was (20 x 10 x 7.5) cm.

Porosity test:-

The porosity test was performed on the prepared samples using the method proposed byFelipe Montes in 2005. All samples within each batch were fairly consistent with porosity. Typically, an acceptable porosity for pervious concrete is between 15% and 25% voids.

$$P\ (\%) = [1–((WD – WS)/ \rho w)/ VT] \times 100$$

Methylene blue test:

This test is also known as color test. The sample with TiO2 put into sun light, then methylene blue dropped on sample. The time recorded till the methylene blue gets degraded. This time was compared with conventional concrete pavement block.

Preparation of Nitrogen dioxide (NO2):

Approximately 95% of emissions in the NOX category are in the form of nitric oxide (NO). However, within the atmosphere NOX compounds can readily be transformed into NO2; therefore, strategies to minimize NO2 pollution often focus on NO emissions. Hence, treat all NOX emissions as NO2. NO2 gas was prepared by using Copper and Nitric acid. For concentrated Nitric Acid the ratio between copper to nitric acid is 1:4 and for diluted on the ratio should be 3:8. We adopted 1:4 ratios for our concentrated nitric acid. We obtained the reddish brown fumes of nitrogen dioxide after mixing of copper with nitric acid.

The balance equation for the reaction of copper with dilute and concentrated nitric acid respectively as follows,

$3Cu + 8HNO3\ (dilute) = 3Cu\ (NO3)2+2NO+4H2O$

$Cu+4HNO3\ (concentrated) = Cu\ (NO3)2+2NO2+2H2O$

Photo-catalytic pavements represent an innovative approach to pollution mitigation which is uniquely suited to near-road environments. When exposed to sunlight, titanium dioxide (TiO2) contained within these pavements generates hydroxyl radicals (● OH). This compound initiates oxidation reactions that convert NO or NO2 into nitrate (NO3), this NO3 remains on the pavements surface.

Fig.2 Actual Test Setup

III. RESULTS AND DISCUSSIONS

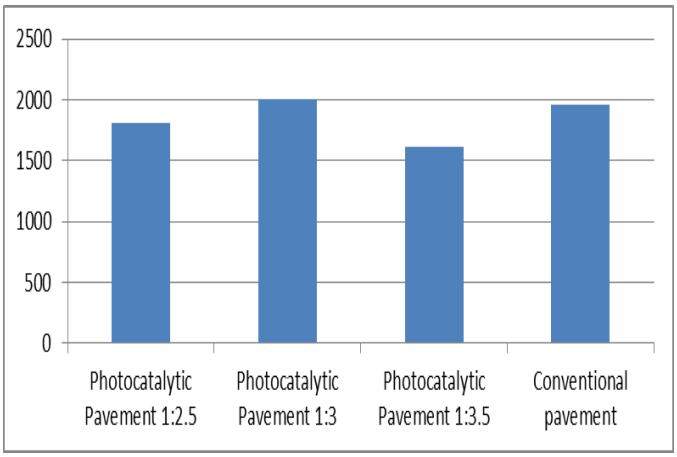

Fig. no.5 Compression Strength Test Result

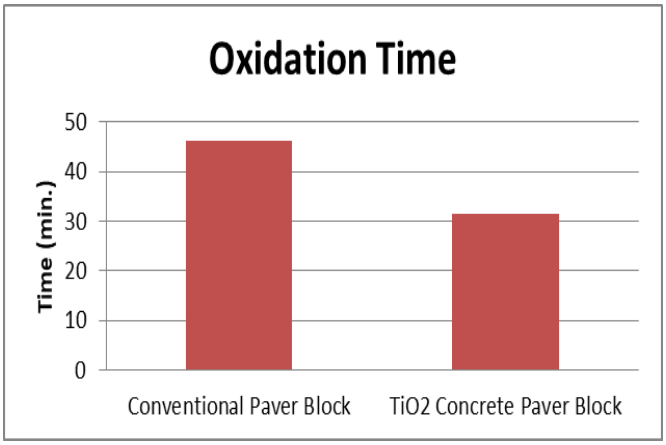

Fig. no.6 Tensile Strength Test Result

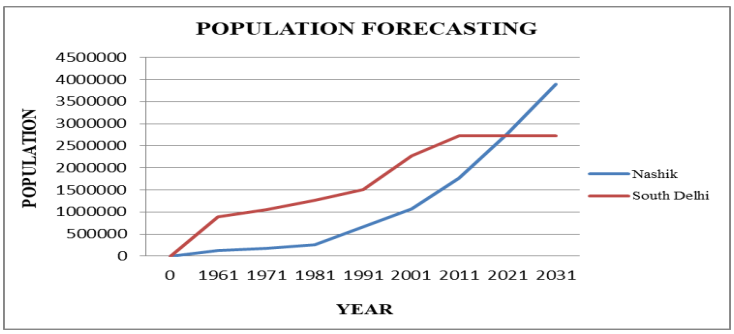

Fig. no.5 Population Forecasting for Nashik

- **DISCUSSIONS**

The TiO2 concrete pavement block with upper layer 1:3 has maximum strength with moderate porosity. We found that the strength of photocatalytic pavement block is more than conventional pavement block. As per strength aspect 1:3 ratio is suitable for TiO_2 concrete pavement block.The titanium dioxide concrete block accelerates the oxidization process. Conventional block shows time require for the natural oxidization process.

Pollution increases with increase in population. The population growth rate of Nashik is very high. In next few years Nashik will have population like South Delhi (2011). The South Delhi district and Nashiks population foresting is shown in Figure 5.

The ambient air quality is very important for any city's growth as well as health. To prevent the air pollution we must take strong designs. Modern methods should be adopted to reduce pollution and to protect the future.

CONCLUSION

With the help of Titanium Dioxide paver block the process of oxidation of pollutants was accelerated. As the urbanization is increasing rapidly and cities are getting crowded day-by-day, there is no place left for vegetation. To improve air quality and to reduce air pollution vegetation plays an important role. So to maintain the health of cities we need to adopt modern techniques to reduce air pollution.

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