Scientific Journal of Impact Factor (SJIF): 4.72

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 4, Issue 4, April -2017

Eco Sensitivity Of Paving Block By Using Titanium Di-Oxide

Air Pollution Control And Storm Water Disposal.

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Abstract — *Due to the increasing population and its large use of vehicles the pollution and its effects on human being is increasing in the urban cities and hence this gave the idea of Eco-Social pavement to come into existence. With this pavement an attempt is being made to reduce this pollution and also an effective disposal of storm-water. In this project an experimental study is carried out for reducing vehicular pollution and storm water disposal. This study includes the step wise procedure for construction of Eco-Social pavement. The field survey consist the material selection for making of pavement and collecting samples for testing. The lab work consist testing of collected samples for proper selection of material for work as per the standard maintained in IS code. The constructed pervious concrete block of sizes 38cm×25cm×8cm by using aggregate of sizes 12.5 mm, 10 mm, and 8 mm with TiO_2 coat on surface of pavement for making of Eco-Social pavement. Three pervious block of each aggregate is used for testing strength, infiltration rate and pollution control test. The test result for pollution control reveals that there is substantial reduction of air contaminants from vehicles, The test conclude that there is 55 % of CO removal and near about more than 50% nitrogen removal in the various form of gases.*

Keywords-TiO2, Air Pollution, Pervious Concrete, Storm Water Disposal, Smog Eating Concrete.

I. INTRODUCTION

Today is the era of industrialization, globalization and modernization. Due to this the nature in 21st century is turning towards devastation. The green cover of earth is reducing hence the problems like global warming arising. But it is not a harmful yet. However in upcoming years this problems may arise more, hence proper steps need to be taken today. Some ecological and social problems in any metropolitan cities are as follows:

1. Increasing population
2. Traffic and industrial pollution
3. Storm water and drainage problems
4. Road accident and health condition
5. Living standard

This are just the highlighted problems which are creating negative impact on urban cities. This problems are arising due to vehicular pollution and ineffective storm water disposal. For that reason the road system is partially responsible for pollution because the road surface does not contribute to control the pollution. That's why the exhaust system of vehicle directly emits the pollution into the atmosphere. To reduce such a problems, applying photo catalytic coating to the pavement on a large scale to reduce air pollution in urban areas.

The photo catalyst, titanium dioxide (TiO_2), is a naturally occurring compound that can decompose gaseous pollutants with the presence of sunlight. Applying TiO_2 to pavement can help remove emission pollutants right next to the source, near the vehicles that drive on the pavement itself. When TiO_2 is applied to pervious pavement, this provides two sustainable benefits in one material; air will be purified on sunny days, and water will be infiltrated on rainy days, in addition to having a rougher surface, which may retain more TiO_2. With this innovative idea, this paper aims to identify the effectiveness of applying TiO_2 to the surface of pervious concrete pavement to produce a greener urban road environment. Several coating methods were compared for their influence on permeability, pollutant removal effectiveness, and their resistance to extreme environmental conditions.

II. TITANIUM DIOXIDE

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, TiO_2 powders were used for white pigments in ancient times. It is used in sunscreen because it can absorb UV light without being consumed in the reaction. Titanium dioxide is white solid inorganic substance that is thermally stable, non-flammable, poorly soluble, and not classified as hazardous. TiO_2, the oxide of metal titanium, occurs naturally in in several kinds of rocks and mineral sands. It is a most common element in earth crust.

2.1 Photo catalytic effect of TiO_2 -

In the sunlight, TiO_2 can have a photo catalytic effect, in which it turns into a "photo-bleach" and degrades fabrics and paint when sunlight is present. A photo catalyst is "a material that uses solar energy to accelerate chemical reactions without being consumed or depleted in the process". Photo catalysis of TiO_2 powders started developing in industrial technology in the 1980s. Heterogeneous photo catalytic reactions have been studied for more than fifty years. Researchers in Europe and Japan had studied photo catalytic compounds and they reduced pollution for over four years. In the sunlight, TiO_2 is activated by ultraviolet (UV) radiation ($\lambda < 390$ nm) to oxidize air pollutants, such as nitrogen oxides (NOx) and volatile organic compound (VOCs), into other inorganic compounds. In a photo catalytic reaction with TiO_2, no chemical reactants are used. The TiO_2 does not get consumed in the reaction; so it can theoretically be used indefinitely. TiO_2 photo catalysis can be performed even in weak UV light. TiO_2 (anatase) has a wide band gap, thus only ultraviolet light with a wavelength below 387 nm is absorbed. Photo catalysts activated by UV lights decomposes the organic materials like components of 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 odours.

2.2 Factors Affecting Photo catalytic Effect :

Photo catalysis can be affected by environmental factors, such as light wavelength and intensity, relative humidity, temperature, and wind. The best results for the photo catalytic effect are with higher temperatures and light intensities greater than 300 nm. An optimal condition to remove air pollutants would be a hot summer day with low relative humidity and no wind. Factors that can affect the photo catalytic effect of TiO_2 when applied to concrete may include porosity, humidity, aggregate type, aggregate size, application method, and applied wear.

III. PERVIOUS CONCRETE

Pervious concrete is concrete with high porosity, which allows water to infiltrate completely through it. It is composed of coarse aggregates, cement, and water. The high void content in pervious concrete is maintained by using aggregates that are generally all one size to avoid filling the voids with fines. The single-diameter aggregates form a framework for pervious concrete, and the aggregates are bound together with cement paste. Because the cement paste that binds the structure together is thin, this reduces the strength of pavement. For this reason, pervious concrete would not be appropriate for highway use, as it would need to accommodate for a high volume of heavy vehicle traffic each day. It could however be implemented on the highway shoulders, which do not carry the repetitive loads of vehicle traffic each day. Also, because pervious concrete has numerous voids exposed to the surface, it is prone to clog with debris, which could hinder water from infiltrating through the structure. It can be prevented with proper maintenance techniques.

IV. MIX DESIGN

The composition design of porous concrete should fulfill the demands of porosity, permeability coefficient and strength according to the material characteristics with the minimum cement dose. The design effective porosity should be 20％-30％, the coefficient of permeability shouldn't be less than 1.05 cm/s.

Step 1: Target mean strength
Fm = fck + k.s
S = 4 …..Assumed considering quality control
Fm = 40 + 1.65×4
Fm = 46.6 Mpa

Step 2: Water cement ratio
W/C = 0.27

Step 3: Water content
For air entrained concrete
Water = 181kg/m^3 …....Stiff plastic.
= 202 kg/m^3 …..Plastic slump 75-100mm

Step 4: Cement content
W/C = 0.27
202/C = 0.27
Cement = 748.148 kg/m^3

Step 5:
Fineness modulus = 2.80
Dry roded bulk volume = 0.46 % of volume of concrete
Density of 10mm aggregate = 2190 kg/m^3
Weight of course aggregate = 0.46×2190
= 1007.4 kg/m^3

Step 6: Weight of ingredients
Cement = 748.148 kg/m^3
Aggregate = 1190 kg/m^3
Water = 202 kg/m^3
Proportions = 1:1.58:0.27 is used

Pervious concrete of strength 20Mpa

Quantities of materials for a volume of (0.38×0.25×0.08=0.0076) m^3 :

Cement	:	5.68 kg
C.A	:	9.044 kg
Water	:	1.5352 kg
Tio2	:	0.456 kg

Table 4.1 :- Details Of Paving Block

Sample	Sample type	Sample size	Aggregate size	Water-cement ratio	No. of blocks
Addition of TiO2 at the time of Mix design	Pervious	38cmx25cmx 8cm	12.5mm 10mm 8mm	0.27	One of each size of aggregat e.
The cement-tio_2 paste coating	Pervious	38cmx25cmx 8cm	12.5mm 10mm 8mm	0.27	One of each size of aggregat e

Table 4.2 :- Materials Proportions In Pervious Concrete

Materials	Mass ratio to cement	Mass for 1 mold
Cement	1	5.68 Kg
Aggregate	1.58	9.044 Kg
Water	0.27	1.5352 Kg

V. INFILTRATION RATE

Table 5.1 :- Observation Table Of Infiltration Test.

Pavement type	Size of block (in cm)	W/C ratio	Result obtained in mm /s	Standard result in mm/s
12.5mm pervious	38×25×8	0.27	22.22	17.37-26.86
10mm pervious	38×25×8	0.27	18.27	15.00- 20.00
8mm pervious	38×25×8	027	5.14	3.00- 10.00

The infiltration rates of the 12.5 mm samples were acceptable, with fast rates ranging from 17.37-26.86 mm/s. The infiltration rates of the 8mm samples were not so fast, with rates ranging from 3-10 mm/s.

VI. POLLUTION CONTROL TEST

This test was conducted to check the efficiency of Eco-Social pavement to absorb vehicular pollution. A was made to make test sample similar to the vehicular condition on the roads. For testing the absorbing capacity of vehicular pollution of pervious pavement we have made a glass box of size 44cm×40cm×40cm. The round hole is left for inserting the pipe from tail end of vehicle exhaust to few centimeters above the pavement.

PUC test on pavement for scooter:

Table 6.1- PUC test result.

Type	Aggregate size	Type of pollutant	PUC before test	PUC after test
Surface coating	12.5 mm	CO% vol.	1.9	1.3
		HC ppm	280	90
	10 mm	CO% vol.	1.7	1.4
		HC ppm	260	70
	8 mm	CO% vol.	1.8	1.6
		HC ppm	280	75
Mixing	12.5 mm	CO% vol.	1.68	0.84
		HC ppm	270	65
	10mm	CO% vol.	1.7	1.1
		HC ppm	240	90
	8 mm	CO% vol.	1.75	1.5
		HC ppm	270	80

VII. COMPRESSIVE STRENGTH

Table 7.1 :- Compressive strength test result.

Type	Block Size (mm)	Aggregate size	Curing Period	Compressive Strength (N/mm^2)
Surface coating	38×25×8	12.5 mm	28 days	10.76
		10 mm	28 days	13.23
		8 mm	28 days	14.37
Mixing	38×25×8	12.5 mm	28 days	11.07
		10 mm	28 days	13.68
		8 mm	28 days	15.11

VIII. RESULTS AND DISCUSSION

8.1 Tests on Aggregate

In this chapter the discussion is made on the various results obtained in this project. The test results are compared with the standard result.

8.2 Water absorption and specific gravity test :

The water absorption value of aggregate is 1.55% and specific gravity is 3.27. The test result of water absorption and specific gravity of used aggregate are within permissible limit hence it is ok.

8.3 Impact test :

Test result: Impact value is 13.65%

Discussion: The impact value is 13.65% which is less than 45%, hence it can be suitable for pervious pavement.

8.4 Crushing strength test :

Test result: The aggregate crushing value is 14.7%.

Discussion: The crushing value of given aggregate is 14.7% which is less than 30%. So it can be suitable for road work.

8.5 Abrasion test :

Test result: Loss Angeles abrasion value is 17.5 %

Discussion: The aggregate abrasion value of aggregate is 17.5% which is less than 30% so it can be used for pavement work.

8.6 Infiltration test :

10 mm size aggregate concrete block gives better result than other two sizes blocks. This block has infiltration rate 18.27 mm/s.

8.7 PUC Test :

10 mm size aggregate concrete block gives adequate result than other two sizes blocks in mixing proportion.

8.8 Compressive strength test :

8 mm size aggregate concrete block gives better compressive strength than other two sizes blocks.

IX. CONCLUSION

The pavement has large surface area that is in contact with polluted air, treating pavements with TiO_2 reduces harmful emissions at street level and benefit a cleaner living environment for the public. Unlike traditional non-pervious pavements, the high porosity and surface roughness of pervious concrete pavement allow more TiO_2 particles to have direct contact with UV lights and thus improve removal efficiency. The open pore structure of pervious concrete also protects TiO_2 particles from traffic loading and environmental weathering. In addition to being a sustainable transportation facility for storm water runoff management, pervious concrete pavement, when coated with TiO_2 and widely implemented in urban roads and highway shoulders, results in improved air quality and thus a multi-phase cleaner transportation environment for future generations.

The test conclude that there is 55 % of CO removal and near about more than 50% nitrogen removal in the various form. The particulate matter and carbon ash settles on the surface of the pavement. This project provides base for future eco friendly environment in urban areas. There is need of constructing the flexible exhaust system of vehicles so as to take dual advantages of pavement and vehicle. There are certain advantages and disadvantages with the construction of Eco-Social pavement.

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