Investigation of Self Cleaning Concrete by Using Titanium Di-Oxide

[1]Hritik S. Behare, [2]Aditya N. Bhosale, [3]Jeevan C. Kadale, [4]Sagar B. Kale [5]Dinesh W. Gawatre

[1234]Student, [5]Faculty Member,
[1]Deapartment of Civil Engineering,
[1]Sinhgad Academy of Engineering, Pune-48 (MS), India.

Abstract : Concrete is the most extensively used construction materials for building technology. But, cement production releases high amounts of carbon dioxide (CO2) to the atmosphere that leads to increasing the worldwide or global warming. Thus, another, environmental friendly construction material such as photocatalyst concrete has been developed. Photocatalytic concrete applies greener alternative binder, which is a modern-day construction material that replaces the Conventional cement. This technology presented nano particles such as nanoclay into the cement paste in order to improve their mechanical properties. The concrete materials also have been developed to be performed as self-cleaning construction materials. The self-cleaning properties of the concrete are induced with the help of photocatalytic materials such as titanium Di-oxide (TiO2). Self-cleaning concrete that contains those photocatalytics will be energized by ultraviolet (UV) radiation and quickens the decomposition of organic particulates. Thus, the spotlessness of the building surfaces can be maintained and the air surrounding air pollution can be reduced. This paper briefly reviews about self-cleaning concrete.

***IndexTerms* - Photocatalyst, Titania, Ultravoilet Radiation, Nano Particles, Nano Clay, Photocatalytic.**

1. INTRODUCTION

A building material eradicate pollutants from the air as it keeps its surface clean. This latest amazing concrete that not only keeps itself clean but also eliminates pollutants from the air is called Self Cleaning Concrete. The crucial factor to such properties are photo catalytic components that use the energy from ultraviolet (UV) rays to oxidize most organic and some inorganic compounds. Air pollutants that would normally result in discoloration of open surfaces are eliminated from the atmosphere by the components, and their residues are washed off by rainwater. So, this latest cement can be used to make concrete and plaster products that save on maintenance costs while they ensure a fresher environment. Interior air in buildings can be more polluted than outdoor air because there are numerous sources of pollution in some large cities.

For decades, scientists have recognized dual exclusive effects of titanium dioxide, a usual compound that is used in products as diverse as quick-setting concrete, tile grout and even suntan lotion. When expose to the sunlight, titanium dioxide (TiO2) acts as a catalyst to break down the organic matter, while also creating a super hydrophilic surface. The useful function of TiO2, which can both serve as photocatalytic materials and structural materials, has facilitated its use in exterior construction materials and interior furnishing materials, such as cement mortar, exterior tiles, PVC fabric, glass and paving blocks.

As such the use of the unique additive promotes self-cleaning of huge concrete structure and at the same time promotes reactions that help in cleansing the environment as well. The properties of photocatalyst are including photocatalytic water purifications and air purifications, self cleaning property and photocatalytic anti-bacterial effect. Its function is limited because of chemical engineering restrictions such as support of photocatalysts or separation of the photocatalysts from the effluent.

Self cleaning or photo catalytic concrete, by the name itself it shows its affordability. The name that it looks like revolutionary ideas and some of us may think that it is impossible. But then again it is practical now, many foreign countries are stick to the concrete for its incredible beneficial results. Concrete construction is a expansive field we can innovate into new creation. By using this concrete cleaning technology, we can create a lovely atmosphere and enhance the anti-aging of concrete. However, this type of concrete produces the indoor air purification so we can reduce the health issues. Breathing problems can be reduced slowly. Protecting concrete not ever creates an aware towards users we can take step to achieve this self-purifying/ cleaning technology to purify the concrete using photo catalyst. Photo catalyst is best filters towards the concrete it creates friendly reactivity over the concrete. The response over the cement is neutral it can be washed away by spraying water it will not create any harm to cement and not affect the cement binding properties. Clean buildings provide astonishing environmental benefit is the potential for cleaner air.

1.1 OBJECTIVES

a) To study environmental sustainability.
b) To study the use of TiO2 as eco-friendly material.
c) To study the methods of reducing air pollution.
d) To reduce patch formations.
e) To keep concrete young.

1.2 NECESSITY

Photocatalytic concrete has the ability to realize air depollution, self-cleaning, plus self-disinfecting. It is fabricated by totalling photocatalyst into traditional concrete, and the best suitable photocatalyst to fabricate photocatalytic concrete is Titanium Di-oxide (TiO2). The photocatalytic reaction can happen under the light when energy is higher than the photocatalyst band gap. The formed highly oxidizing hydroxyl radicals can react with contaminants and create carbon dioxide, water, or other harmless substances. The decomposed pollutants can be taken away by wind or rain to attain the purpose of air depollution and self-cleaning. The photocatalytic concrete has immense capacity in the field of degradation of pollutants, deodorization, sterilization, and energy conservation.

1.3 Application

The use of photocatalysts in concrete technology is by now a well- founded concept. However, despite the big opportunities for air quality improvements to be derived from the considerable concrete surfaces exposed to the atmosphere, mainly in cities where air quality is greatly affected by vehicle exhaust plus industrial area emissions, Photocatalytic concretes are still not in mainstream function. With current levels of NOx pollution considerably exceeding EU legislative rules in urban centers throughout the industrialized globe, it is important to consider what the issues are. The likely obstructions to more widespread implementation are likely to contain cost effectiveness, which needs to be related to photocatalyst impact, but the challenges in measuring impact on air quality directly are complex. This paper seek out to place photocatalytic efficiencies into context, equating performances of the traditional photocatalyst dispersion in surface mortar coatings with that of photocatalysts supported on open or exposed surface aggregates. The nature and influence of catalyst binding to the aggregate is also discussed in this paper.

2. Methodology

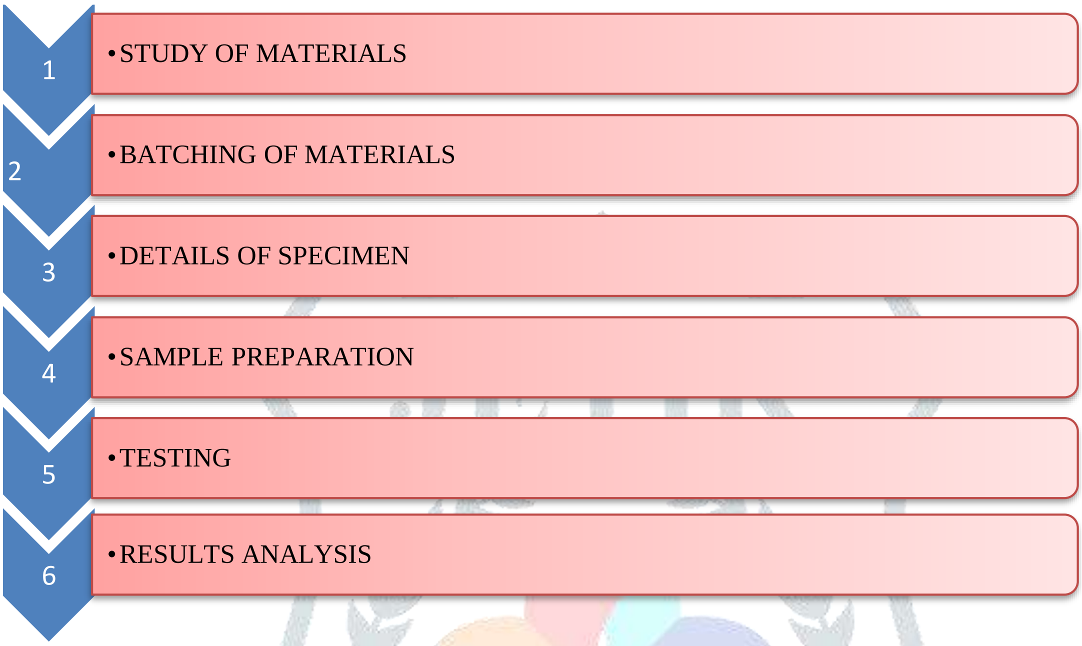

Fig 1: Methodology Flow Chart

2.1 Study of Materials

2.1.1 Ordinary Portland Cement

Cement is a material having both cohesive as well as adhesive properties in the presence of the water. Such cements are called hydraulic cements. Cement is also a binding material in the concrete, which binds the extra materials to form a compact mass. Generally Ordinary Portland Cement is used for all Engineering Construction works. Ordinary Portland Cement (OPC) is available in three grades of 33, 43, and 53. We have used, 53 grade cement in this project for the experimental study. Ordinary Portland cement will be used for the present study (grade 53). The physical properties of cement are presented in Table 1**.**

Table 1: Physical Properties of Cement

Sr No.	Properties	Values
1	Specific Gravity	3.15
2	Standard Consistency (%)	31
3	Initial Setting Time (Minutes)	44
4	Final Setting Time (Minutes)	384
5	Fineness	7%

2.1.2 Fine Aggregate

Concrete with better quality can be made with sand consisting of rounded grains rather than angular grains .River or manufactured sand must be used and not sea sand as it contains salt other impurities. Manufactured sand is a alternative of river sand for concrete construction. Manufactured sand is made from hard granite stone by crushing. The crushed sand is having the cubical shape with grounded edges is washed and graded to as a construction material. The size of manufactured sand is less than 4.75mm. Table 2 below shows the properties of river sand and manufactured sand. Natural fine aggregate will be used for the experimental study is manufactured sand. The physical properties of fine aggregate are presented in Table 2.

Table 2: Physical Properties of FA

Sr No.	Properties	Values
1	Water Absorption (%)	1
2	Specific Gravity	2.74
3	Bulk Density (kg/l)	1.31
4	Fineness Modulus	3.476
5	Uniformity Coefficient (D60/D10)	5.677
6	Effective Size (D10)	0.155
7	Grading Zone	Zone II

2.1.3 Coarse Aggregate

Coarse aggregates are mined from rock quarries or dredged from river beds, so the shape, size, hardness, texture and numerous other properties can vary significantly based on location. Most commonly, coarse aggregate can be characterized as either smooth or rounded or angular. Because of this inconsistency, test methods exist to characterize the most relevant characteristics since exact identification would not be possible. Several main characteristics that are often used to explain the behaviour of coarse aggregates include relative density (or specific gravity), bulk density, and absorption. Crushed granite angular aggregate from a local source, having a maximum size of 20mm, will be used for the present study. The physical properties of natural coarse aggregate are presented in Table 3.

Table 3: Physical Properties of CA

Sr No.	Properties	Values
1	Water Absorption (%)	0.5
2	Specific Gravity	2.74
3	Bulk Density	1.5 (g/cc)
4	Fineness Modulus	4.309
5	Uniformity Coefficient (D60/D10)	1.29
6	Effective Size (D10)	15.523

2.1.4 Titanium Di-oxide

Titanium dioxide is a chemical compound, also known as titanium oxide or titania, is the naturally occurring oxide of titanium, chemical formula TiO2. The photo catalytic activity, which is another property of TiO2, is increased considerably through the high surface-to-volume ratio of the nanoparticles as compared to that of micro particles.

Scientific investigations on photo catalysis started about 25 years ago. Titanium-dioxide (TiO2), which is one of the most common materials in our daily life, has emerged as an exceptional photo catalyst material for green environmental purification. In this review, current growth in the area of TiO2 photo catalysis, primarily photo catalytic air purification is studied. Photo catalysis takes place only when the surface is treated with Ultraviolet light or sun light. Molecular formula of Titanium Di Oxide is TiO2 and its molecular weight is 79.87, it is a kind of powder. Titanium dioxide colour is white. Formula for titanium dioxide is TiO2.

Table 4: Physical Properties of Titanium Di-oxide

Sr No.	Properties	Values
1	Average Particle Size	35
2	Specific Gravity	1.34-1.4
3	Density (g/cm3)	0.25
4	Purity (%)	99%
5	Colour	White

2.1.5 Rhodamine B Dye

It is a chemical compound and a dye. It is every so often used as a tracer dye within water to find the rate and direction of flow and transport. Rhodamine dyes fluoresce and can therefore spotted easily as well as economically with instruments which are called as fluorometers. Rhodamine dyes are used widely in biotechnology uses such as fluorescence microscopy, ELISA, fluorescence correlation spectroscopy and flow cytometry.

2.2 Batching of Materials

Volume batching is not suitable method for proportioning the material because of trouble it offers to measure granular material in terms of volume. Volume of moist sand is loose conditions weighs much fewer than the equal volume of dry compacted sand. The total amount of solid granular material in meter cube is indefinite quantities because of this for good quality concrete materials have to measure by weigh only.

2.3 Details of Specimen

The cube specimens of 150 x 150 x 150 mm were cast for control mix (CM) as per mix design.

2.4 Sample Preparation

While casting cubes, to study the properties of concrete with partial replacement of cement by titanium dioxide. The compressive strength of cubes after replacing cement by 3%, 4% and 5% is check for after 28 days for test specimens, 53 grade Portland cement, manufactured sand and coarse aggregate, titanium dioxide are being utilized. The maximum size of the coarse aggregate was restricted to 20mm or 2cm. The concrete mix proportion water cement ratio of 0.4 were used.

The concrete cube (15 x 15 x 15 cm) for conventional as well as other mixes were casted. Each layer was compacted with 25 no. of blows using 16mm diameter rod.

2.5 CURING

Concrete attains its strength by hydration of cement. The hydration of cement is not a temporary action but a process on-going for long period. Of course, the rate of hydration is quick to start with, but continues over a extremely long time at a falling rate. The amount of the product of hydration and consequently the amount of get formed depends upon the amount of hydration. It has been stated earlier that cement needs a w/c ratio about 0.23 for hydration and a w/c ratio of 0.15 for filling the voids in a gel pores. In different works, a w/c of about 0.38 would be necessary to hydrate all the particles of cement and also to occupy the space in the gel pores.

Fig 2: Curing

2.6 TESTING

2.6.1 Tests Performed

- a) Compressive Strength Test
- b) Rhodamine B Dye Decolourization Test

a) Compressive Strength Test:

Compressive test is the very usual test performed on hardened concrete, since it is an easy test to perform the partly because of the desirable characteristics properties of concrete are qualitively connected to its compressive strength test. The tests can be performed on UTM or CTM and load and compressive load is noted for the ultimate failure. The compressive test is carried out on specimens which are having a cubical or cylindrical shape. The cube specimen is of the size 15cm x 15cm x 15cm. The test cube specimens are prepared as soon as practicable after mixing and such a way as to produce full compaction of the concrete with neither segregation nor excessive laitance. The concrete is filled into mould in various layers approximately about 50mm or 5cm deep. The tests are done on an electro-hydraulically operated compression-testing machine and compressive load is applied on opposite faces axially, slowly at the rate of 140 MPa/minute. The compressive load is then observed and noted for the ultimate failure. In this project the cement will be partially replaced by titanium oxide in 3%, 4%, and 5% by weight of cement. The specimens will be casted and cured. The compressive strength of concrete will be determined as per Indian Standard specification.

Fig 3: Digital Compression Testing Machine

Fig 4: Testing of Cubes

b) Rhodamine B Dye Decolourization Test:

In this test concrete containing TiO2 photocatalyst have been evaluated based on decolourization under sunlight, it's a standard test for self cleaning cementitious material. Experimental data are discussed in relation to dye decolourization of 3%, 4% and 5% of TiO2 replaced concrete under sunlight. On surface of the casted concrete cubes 1ml of rhodamine dye is dropped on each cube sample and placed under direct sunlight and results were observed and recorded. The decolourization of rhodamine dye occurs on the surface of the cubes after some hours.

The observations of Rhodamine B Dye Decolourization Test shows that the value of decolourization increases when the percentage of TiO2 increases.

3. Result Analysis

3.1 For 3% of TiO2

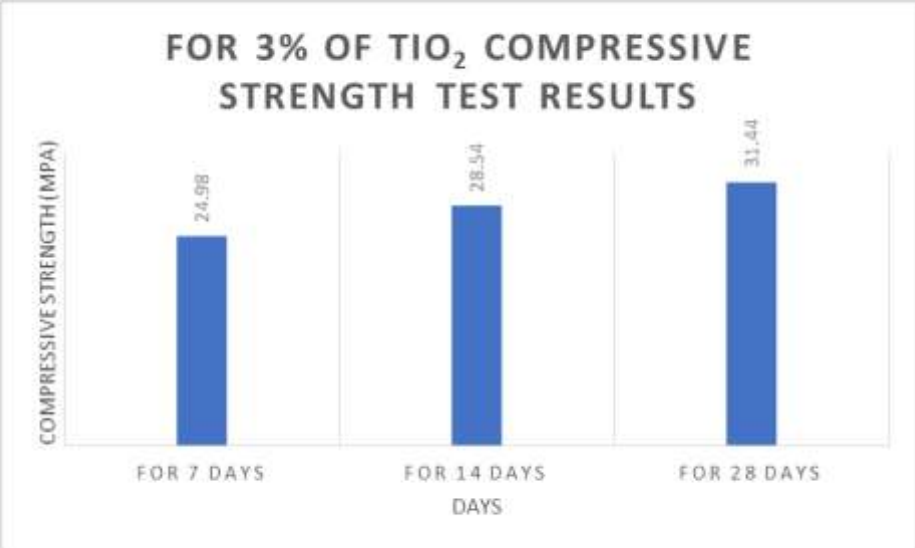

Fig 5: Graphical Representation of results for 3% of TiO2

3.2 For 4% of TiO2

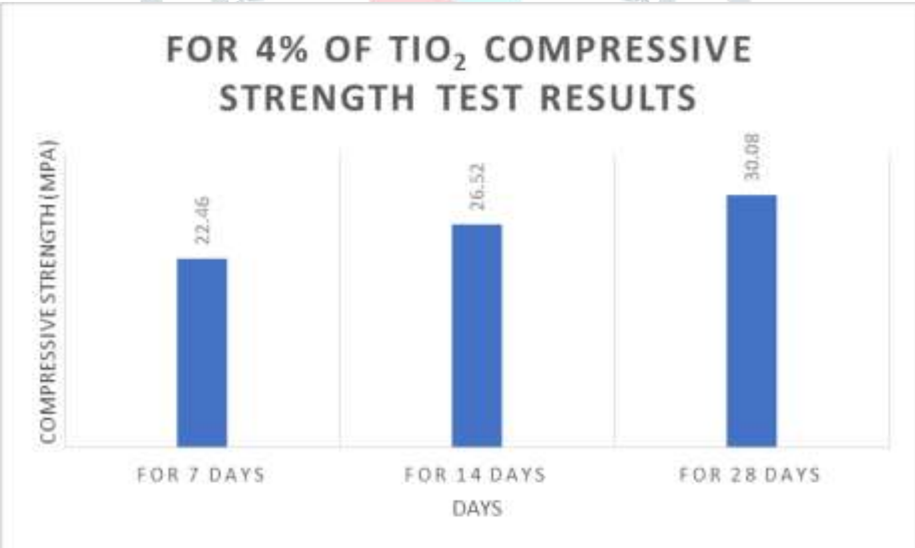

Fig 6: Graphical Representation of results for 4% of TiO2

3.3 For 5% of TiO2

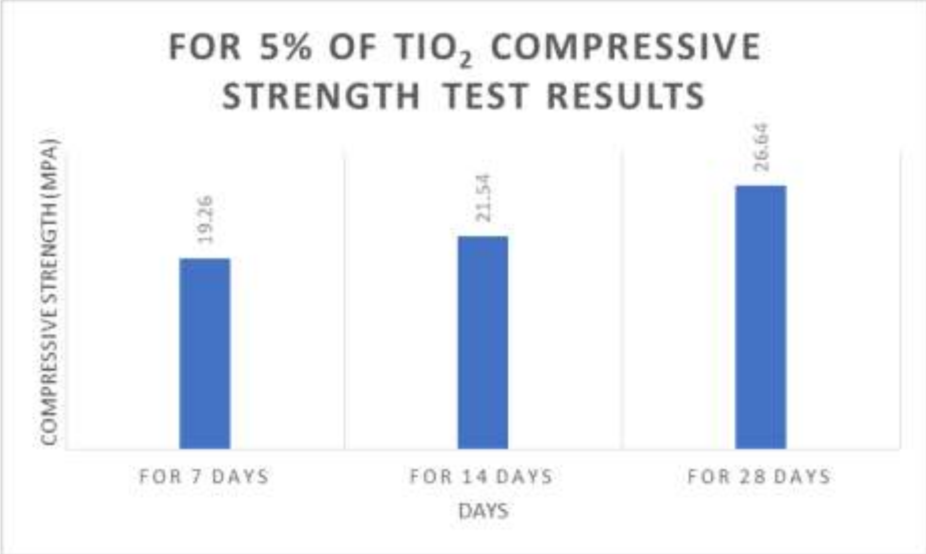

Fig 7: Graphical Representation of results for 5% of TiO2

3.4 Comparison of Compressive Strength

Table 5: Comparison of Compressive Strength

Days	3% TiO2	4% TiO2	5% TiO2
For 7 days	24.98	22.46	19.26
For 14 days	28.54	26.52	21.54
For 28 days	31.44	30.08	26.64

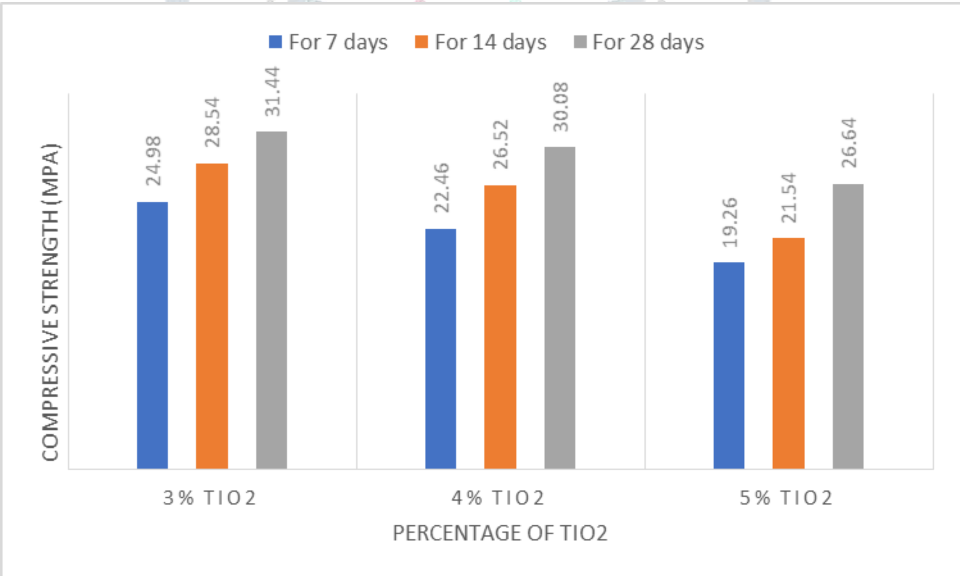

Fig 8: Graphical Representation of Comparison of Compressive Strength

4. Conclusion

a) The concrete in which cement is partially replaced by 3% of titanium dioxide shows gradual increase in compressive strength and further increase in amount of TiO2 Compressive strength goes on decreasing.

b) Compressive strength of concrete sample with 3%, 4% and 5% of titanium dioxide after 28 days curing is higher than the target mean strength.

c) The decolourization test results show that when the titanium dioxide content is high then the decolourization is also high. The situation is obtained on sunny days, with no wind.

d) The amount of TiO2 in concrete is inversely proportional to time of Decolourization i.e. as amount of TiO2 increases time of decolourization decreases.

e) From above study it is better to use the concrete sample with 4% of titanium dioxide for strength and decolourization of rhodamine dye.

5. Future Scope

a) To examine high pollution regions in India and assess the interplay between pollutant concentrations.
b) To detect regions where photocatalytic concrete infrastructure has the capacity to be most effective based on the experimental outcomes.
c) To reveal the influence of environmental conditions, particularly temperature, on the photocatalytic pollution degradation mechanism in order to develop a correlation between photocatalytic effectiveness and seasonal climate.

5. References

1) Weiguo Shain, Chuang Zhang, Qiu Li, Wensheng Zhang, Liu Cao, Jiayuan "Preparation of TiO2 Nano particle modified photocatalysts self cleaning concrete." Science Direct Journal of Cleaner Production 87 (2015) 762-765 Published in 2014.
2) Anurag Raj. "Behavior of self cleaning concrete by using various photocatalysts." IRJET Volume: 06 Issue: 05 | May 2019
3) Dr. S. U. Kannan, Jebin Raj, Jerom Antony, Manoj, Mujahid "Study on the Properties of Self Cleaning Concrete using TiO2." IJTSRD ISSN No. 2456 – 6470 Volume – 2 Issue - 5 2018
4) Arafa Awadalla, Muhammad Fauzi Mohd Zain, Abdul Amir H. Kadhum, Zeinab Abdalla. "Titanium Dioxide as Photocatalytic to create self cleaning concrete and improve indoor air quality." IJPS ISSN 1992 - 1950 ©2011
5) Adnan Mujkanović , Dženana Bečirhodžić , Nevzet Merdić. "Self-cleaning concrete – a construction material for building cleaner world." 20th International Research/Expert Conference Oct 2016
6) Rajamuniasamy, Mercy, Praveen, Devan, Shindo. "Experimental study on self cleaning concrete by replacing cement by titanium dioxide." IJSRR ISSN NO: 2279-543X Volume 7, Issue 11, 2018
7) Anne BEELDENS. "An environmental friendly solution for air purification and self-cleaning effect: the application of TIO2 as photocatalyst in concrete." 2012
8) S N Zailan, N Mahmed, M M A Abdullah, A V Sandhu. "Self-cleaning geopolymer concrete - A review." 2017
9) T.Vignesh, A.Sumathi, K. Saravana Raja Mohan. "Study on Self-Cleaning Concrete Using Nano-liquid TiO2." IJET 7 (3.12) (2018) 860 -863, 2018
10) Abhijeet Shukla, Rao Faraz Waris, Mohd. Arhab, Syed Sajid Husain. "A Review on Pollution Eating and Self Cleaning Properties of Cementitious Materials." IJIRSET Vol. 7, Issue 3, March 2018
11) C. Visali , A.K. Priya, R. Dharmaraj "Utilization of ecofriendly self-cleaning concrete using zinc oxide and polypropylene fibre" 14th June 2020
12) D.W. Gawatre "Study of Various Fineness of Fly Ash as a Partial Replacement of Cement in Concrete" IJSER Volume 4 issue 1 January 2013.(ISSN 2229-5518) January 2013
13) D.W. Gawatre "Advantages of Green Building" IJSR Volume 2 Issue 4 April 2013 (ISSN: 2277-8179).pp 68-70 April 2013
14) Aditya Bhosale[1] , Hritik Behare[2] , Jeevan Kadale[3] , Sagar Kale[4] , Dinesh W. Gawatre[5] "Review Paper On Photocatalytic Concrete Using Titanium Di-Oxide" IJSART Volume 7 Issue 5, May 2021
15) IS 456: 2000 – Code of Practice for Plain and Reinforced Concrete
16) IS 10262: 2009 – Guidelines for Concrete Mix Proportioning
17) IS 12269: 2013 – Specification of Ordinary Portland Cement, 53 Grade
18) IS 650: 1991 – Specification for Standard Sand for testing of Cement
19) IS 383: 1970 – Specification for Coarse and Fine Aggregate from Natural Sources of Concrete
20) IS 516: 1959 – Method of test for Strength of Concrete
21) "Concrete Technology" by M. L. Gambhir
22) "Chemistry of Cement and Concrete" by F. M. Lea