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Dispersion Characteristics and Flexural Behavior of Concrete Using Nano Titanium Dioxide

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Abstract: Cement is one of the most commonly used construction materials due to its low cost, high mechanical strength and workability. The mechanical behavior of concrete materials depends to a great extent on structural elements and phenomena which are effective on a micro- and nanoscale. The ability to target material modification at the Nano structural level promises to improve significantly the mechanical performance, volume change properties, durability, and sustainability of concrete. In recent years nanotechnology has become very active in research areas due to its smaller size and high surface area. Nano technology has attracted considerable scientific interest due to the new potential uses of particles in the order of nanometer (10-9 mscale. Nanomaterials have a larger value of the ratio between surface area and volume than other similar particles in larger size, making the nanomaterials more reactive. The focus of this study was to explore the useof nanotechnology-based nano filament, TITANIUM DIOXIDE (TiO_2), as reinforcement for improving the mechanical properties of Portland cement paste. In order to maintain good workability of concrete conplast was utilized in the present investigation. Furthermore corrosion resistance and setting time of concrete are also monitored. Dispersion characteristics of Nano TiO_2 were also monitored with the help of X – RAY Diffraction test. Flexural behavior of this concrete was monitored with the help of a structural member. These propertiesgive the importance of TiO_2 as an additive to the improvement of properties of cement.

Keywords: *Nano titanium Dioxide, mechanical properties, X ray diffraction, Flexural behavior*

1. Introduction

Recent developments in the areas of nano materials science and nanotechnology are changing the field of construction and building industry. The construction industry has been increasingly identified as an important market for the use of nano material's since as they can make buildings cleaner (minimizing the pollution effects and also reducing the building facades maintenance costs), resistant and energy efficient (thermal energy storage). These are very important features in cities characterized by having a densely urban environment.

Since the discovery of the photo catalytic properties of some semiconductor materials, several investigations have been made to characterize the potential of the addition of these materials to construction materials aiming at improving the functional properties in view of achieving more sustainable materials. The photocatalytic property can be defined as the ability of a material under UV irradiation from solar light, together with the presence of water molecules, for promoting the formation of substances that have a strong oxidizing potential and win reaction to some organic and inorganic resulting in its disintegration. Among the semiconductor with photo catalytic properties based on oxides and sulfites, it can be highlighted the titanium dioxide (TiO_2), zinc oxide (ZnO), Tungsten oxide (WO_3). However, the titanium dioxide has been taken the major attention due its high photocatalytic activity, chemical stability, availability and cost. Even though known since the sixties, the self-cleaning ability associated to photocatalytic activity only recently have been taken advantage of. The concrete with self-cleaning properties was firstly used in the church "Dives in Misericórdia" designed by architect Richard Meyer in pre-fabricated concrete blocks, made with white cement and containing TiO_2 in its composition. This approach can result in the reduction of cost with the maintenance of the buildings, becoming them more sustainable.

Researchers have also noted that the addition of fine fillers to Portland cement can change the early hydration reaction of cement with potential implications relating to setting time, dimensional stability and strength development. Acceleration in the hydration reaction has been observed when fine fillers were added to cement. However, the addition of fine fillers could also affect the dimensional stability of a cement mix by increasing shrinkage of the cementitious material. The particle size of the filler could be optimally selected, so that the filler could increase the hydration reaction but not significantly affect the dimensional stability of the cement system.

Addition of a fine non-reactive filler to cement modifies the hydration reaction primarily due to dilution, modification of particle size distribution and heterogeneous nucleation. Most of the fine fillers

previously examined react chemically to some extent in the cement hydration process. There is an increasing interest in the addition of inert additives to cement. Titanium dioxide (TiO_2) is added to cement for its photo catalytic activity, which can impart self-cleaning, and smog-abating functionality to cement based materials. Research has shown that the photo catalytic activity is superior in nano crystalline Anatase TiO_2. Apart from photocatalytic activity, its mechanical properties and durability is also monitored. Microstructure plays a major role in mechanical properties. Hence X ray Diffraction is carried out to understand the microstructure. Flexural behavior was found by casting a structural member.

2. Material Properties

The properties of materials used in the concrete are discussed below:

2.1 Cement

Ordinary Portland cement of 53 grades available in local market was used. The specific gravity of cement that was taken was 3.14

2.2 Fine Aggregate

The sand sieved through 4.75 mm sieve is used having specific gravity of 2.6. The fine aggregates belonged to grading zone I.

2.3 Coarse Aggregate

Locally available coarse aggregate having the maximum size of 12.5 mm is used. The specific gravity of coarse aggregate that was taken was 2.67

2.4 Nano Titanium Dioxide

Titanium Dioxide is used as a replacement for cement. The average size of Titanium Dioxide is 50 nm.

Figure 1 *Titanium Dioxide*

2.5 Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Potable water available in the laboratory was used.

2.6 Super plasticizer

SulphonatedNapthalene Formaldehyde based super plasticizer was used with the brand name Fosroc Conplast SP430 DSI. Dosage of super plasticizer is 1% of cementations material. The specific gravity of super plasticizer is 1.145. It is a dark brown liquid in color.

Figure 2 *Conplast*

3. Experimental Investigation

In this investigation the hardened properties of concrete for various replacement percentages of Nano Titanium Dioxide was determined.

3.1 Mix proportions

Based on the IS 10262: 2009 codal provision mix proportions of concrete were prepared for M30 grade.

3.2 Hardened properties of concrete

In order to find the mechanical properties Compressive strength tests were conducted at 28 days of cube (150 X 150 X 150 mm) specimens. For each combination, two specimens were tested.

In order to find the split tensile strength of concrete 28 days of cylinder (100 X 200 mm) specimen are cast. For each combination, two specimens were tested.

Figure 3 *Compressive Strength Test*

The following tables give the Compressive strength values of concrete:

Table 1: *Compressive Strength of concrete*

S. No	Percentage Replacement	Compressive Strength	
		7 Days (n/mm^2)	28 Days (N/mm^2)
1	0	22	33
2	0.5	24	35
3	1	26	38
4	1.5	22	30

Following figure indicates the variation of compressive strength of nano concrete with respective replacements.

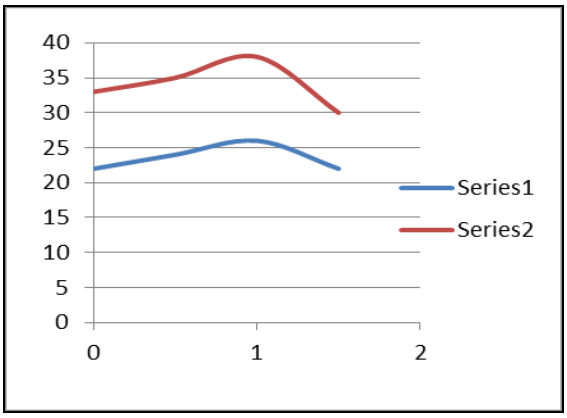

Figure 4 *Compressive strength of concrete*

From the above figure, series 1 indicates the 7 days compressive strength. Series 2 indicates 28 compressive strength.

Figure 6 *Split tensile strength*

The following table gives the values of split tensile strength of concrete:

Table 2: *Split tensile strength of concrete*

S.no	Percentage replacement	Split tensile strength	
		7 Days(N/mm^2)	28 Days(N/mm^2)
1	0	3.01	3.45
2	0.5	3.18	3.54
3	1	3.21	3.76
4	1.5	2.92	3.65

The following figure shows the variations of split tensile of concrete with respective replacements.

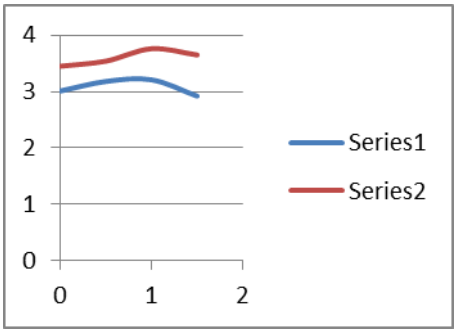

Figure7 *Split tensile strength of concrete*

4. Microstructure of Concrete

In order to find the microstructure of the concrete the X Ray Diffraction test is carried out in the Department Of Nanoscience and Technology, Sri Ramakrishna College of Technology, Coimbatore.

Three samples were tested, 0.5%, 1%, 1.5% of replacement of cement by nano titanium dioxide. The result incurred as follows.

From the below table 2theta and counts are obtained from the tabular column of the result of X ray diffraction Samples of 0.5%

Table 3: *XRD result for 0.5%*

2 THETA	COUNTS
26.4	31.74
33.23	0.48
36.4602	2.58
44.661	5.86
46.9626	3.78
50.161	10.94
57.1079	2.46
59.8166	3.99
64.2804	1.52
67.8513	20.76

Following graph shows the variation between 2theta and counts.

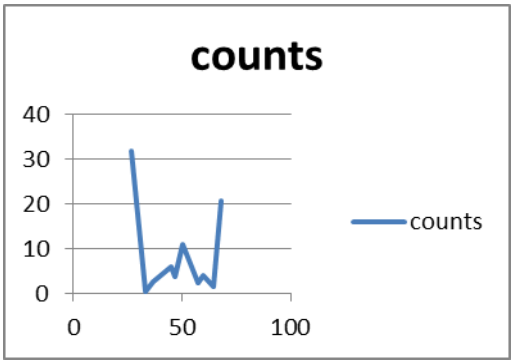

Figure 8*.XRD result for 0.5%*

Following table and graph shows the result for 1% replacement

Table 4: *XRD result for 1%*

2THETA	COUNTS
26.4377	36.77
29.24	2.82
36.181	0.07
44.8539	2.55
54.4594	2.35
59.8409	38.15
67.8126	23.23
75.5545	2.54

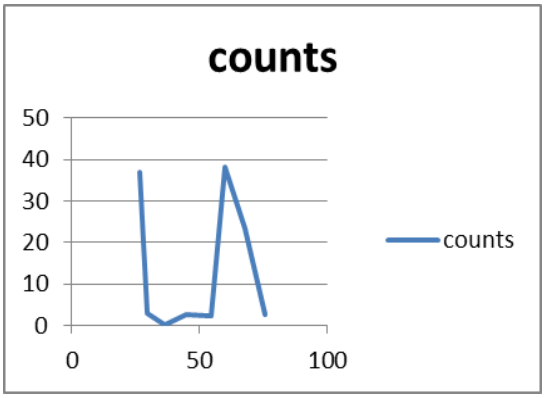

Figure 9*.XRD result for 1%*

Following table and graph shows the result for 1.5% replacement.

Table 5: *XRD result for 1.5%*

2Theta	Counts
27.3493	90.48
29.6145	8.1
35.5782	0.28
41.9979	2.45
49.7275	1.8
54.4331	1.83
59.7894	8.58
68.0777	7.74
73.3817	9.38

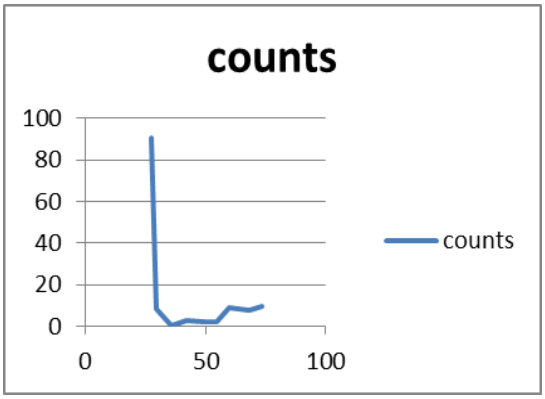

Figure 10*.XRD result for 1.5%*

From the results obtained from the X ray diffraction it is observed that the replacement of cement by 1% replacement provides uniform dispersion into the concrete when compared to the others.

5. Flexural Behavior of Concrete

Flexural behavior of control mix concrete and optimum mix concrete was tested and the readings are tabulated below. Nano Titanium dioxide was replaced with cement .by mechanical testing 1% of replacement was found to be optimum.

Table 6: *Flexural Behavior for control and optimum percentage*

Nominal Mix		1% Replacement	
Load (KN)	Deflection (mm)	Load (KN)	Deflection (mm)
0	0	0	0
10	0.14	10	0.12
20	1.21	20	0.98
30	2.13	30	1.56
40	2.87	40	2.53
50	3.61	50	3.1
60	4.16	60	3.53
55	8.22	70	4.12
		65	6.7

Following figure shows the relation between load and deflection for the nominal mix concrete and optimum mix concrete.

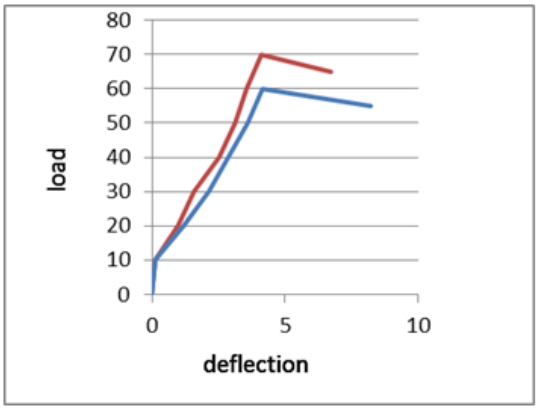

Figure 11. *Flexural Behavoir of beam*

From the graph it is found that the flexural behavior of optimum percentage beam provides better results.

6. Conclusion

Basic properties, consistency, setting time, fineness, and specific gravity, of a binder material (cement) were found out in this present investigation. Mix design confirming to grade of concrete M30 was found out according to the IS codal provisions were calculated and tabulated. Relation between Black conplast and cement matrix were observed in order to maintain good work ability. It was found out that 1% replacement of conplast by cement could improve workability of cement mortar up to 100%. By adding 1% of conplast, the performance of concrete is observed by adding Nano TiO2 into the concrete mix.

It is found out that the replacement of Nano titanium dioxide by1% provides better results, and is acts as an optimum value.

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