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Effect on Flexural Strength of Concrete by Addition of Nano Titanium Dioxide and Nano Calcium Carbonate

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Abstract: ***In this paper, resulting change in flexural strength of concrete by the addition of Nano materials are studied. The concrete is prepared by adding Nano titanium dioxide and Nano calcium carbonate by weight. Two types of concrete were prepared by adding Nano titanium dioxide and Nano calcium carbonate. In concrete containing Nano titanium dioxide is prepared by adding 0.5%, 1%, 1.5% and 2% by weight of cement.In concrete containing Nano calcium carbonate is prepared by adding 0.5%, 1%, 1.5% and 2% by weight of cement. Eight sets of specimen is prepared and compared with control concrete. Adding 2% TiO_2 shows maximum improvement in flexural strength, in Nano $CaCO_3$ concrete adding 0.5% content of Nano $CaCO_3$ shows maximum strength.***

Keywords: Nano-$CaCO_3$, Nano-TiO_2, concrete, flexural strength

1. Introduction

Concrete which is subjected to the pavement undergoes load in a cyclic pattern. Due this repeated loads the concrete under goes failure. Failure occurs in the form of cracks, wear and tear. To minimise this effect it is necessary to introduce some material in construction to increase the strength of concrete. The second thing is that to material will be used should not be used in huge quantity to increase the cost of construction for the same amount of material for concrete. The Nano materials when added in concrete are improving the strength due to their size effect, quantum effect, surface effect and interface effect. [1, 2, 3]. The concrete produced by replacing cement in small quantity leads to better enhancement in strength. Liu Xiaoyan reported decrease in setting time with 20% increase in flexural strength at 1% replacement of cement by nano$CaCO_3$ [3]. Nazari Ali reported 20 % increase in the flexural strength at 1% TiO_2 content [4]. Nazari Ali reported 50 % increase in the flexural strength of concrete at 4% TiO_2 content [5]. Lucas S.S. reported that addition of TiO_2 nano particles increases the NO_x degradation of mortar; containing 5% Nano TiO_2 and 19% gypsum and is maximum at this level of replacement [6]. Jalal Mostafa reported 42% increase in flexural strength at 4% TiO_2 replacement from cement [7]. There are various application of Nano materials in concrete. There are various Nano materials available such as Nano SiO_2 , Nano TiO_2 , Nano Al_2O_3 , Nano Fe_2O_3 , nano $CaCO_3$ etc. Nano-titanium dioxide and nano-calcium carbonate are used in this study. Considerable amount of TiO_2 results in increase in strength of the concrete.

2. Materials and Methods

Table 1 Materials

Particulars	Type	Specific gravity	fineness
Cement	Portland Pozzolana Cement (prism) Fly ash based conforming to (IS: 1489-1991)	2.9	2% on 90 micron sieve
Coarse aggregate	20mm and 10mm size crushed granite	2.70	0.1%
Fine aggregate	River sand (Zone 2)	2.60	1%
Water	Fresh drinking water(pH value 6-7), free from impurities		

Nano Materials

The properties of the Nano materials which are provided by the supplier are mentioned below:

Table 2: Properties of Nano Materials

Properties	TiO_2	$CaCO_3$
Purity	99%	99%
Particle size	0.3 to 0.5µm	Mean 0.8 and Max 5 µm
Specific gravity	3.85	2.91

* Nano materials are purchased from Sakshi Dyes and Chemicals Delhi.

Details of Samples

A total 3 sets of specimens are prepared in the laboratory. First series consist of control mixture which was made of natural aggregates, cement and water. The Nano TiO_2 concrete are prepared by adding Nano TiO_2 in doses of 0.5%, 1%,1.5% and 2% by weight of cement. Nano $CaCO_3$ concrete is prepared by adding 0.5%, 1%, 1.5% and 2% by weight of cement. For flexural strength the specimens prepared by using beam moulds of size 100mm x 100mm x 500mm.

The samples are prepared by adding Nano materials by weight of cement. The details of sample are given below:

Table 3: Details of samples

Concrete	Sample name	Nano TiO_2 (%)	Nano $CaCO_3$ (%)
Control mix	CO	--	--
TiO_2	T1 T2 T3 T4	0.5 1.0 1.5 2.0	--
$CaCO_3$	C1 C2 C3 C4	--	0.5 1.0 1.5 2.0

3. Experimental Result and Discussion

Flexural strength of specimens at 7, 14 and 28 days obtained by testing on flexure testing machine in the institute laboratory. Tests are carried out on triplicate specimens at specified curing period of 7, 14 and 28 days. Average value of flexural stress for each type of concrete at different ages is reported. The flexural testing machine used for the test is shown below

Figure 1: Test set up for flexural Test

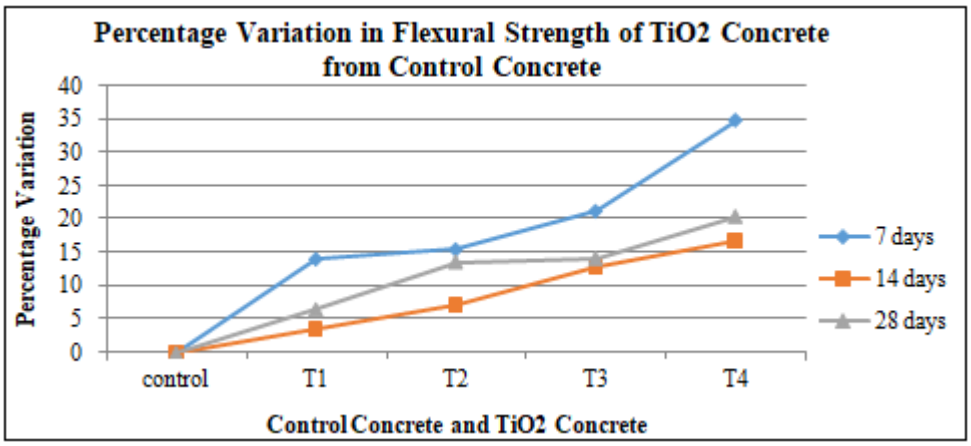
Figure 2: Specimen after Test

Table 4: Flexural strength of the control and TiO_2 blended cement concrete and percentage strength variation from control

Sample designation	Nano TiO_2 particle (%)	7 days	14 days	28 days
		Percentage variation From control	Percentage variation From control	Percentage variation From control
Control	0	00.00	00.00	00.00
T1	0.5	+14.04	+3.63	+6.51
T2	1	+15.47	+7.27	+13.62
T3	1.5	+21.19	+12.90	+14.14
T4	2	+34.76	+16.72	+20.36

* Water to binder [cement + Nano $TiO2$] ratio = 0.5

The flexural strength of TiO_2 concrete increases with the increase in percentage of Nano TiO_2at all ages of curing. It can be further increase by increasing the percentage of Nano TiO_2 beyond 2%.



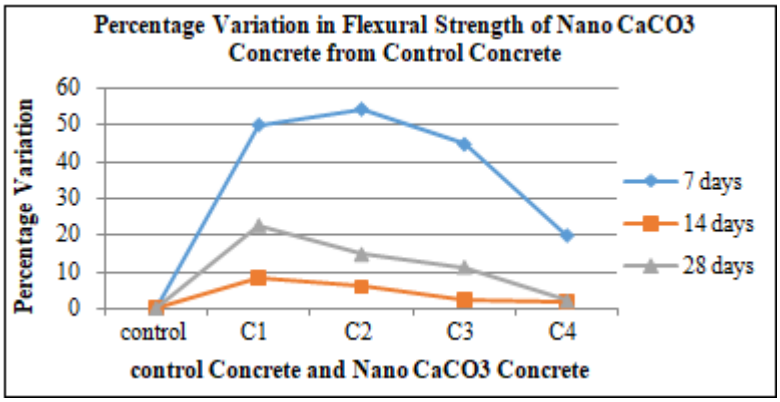
Graph 1: Flexural strength of TiO_2 at various dosages

Table 5: Flexural strength of the control and $CaCO_3$ blended cement concrete and percentage strength variation from control

Sample designation	Nano $CaCO_3$ particle (%)	7 days	14 days	28 days
		Percentage variation From control	Percentage variation From control	Percentage variation From control
Control	0	+00.00	00.00	+00.00
C1	0.5	+49.76	+8.50	+22.61
C2	1	+54.04	+6.00	+14.74
C3	1.5	+44.50	+2.18	+11.23
C4	2	+19.76	+1.60	+1.96

* Water to binder [cement + Nano $CaCO_3$] ratio = 0.5

At 7 days the maximum flexural strength is achieved in C1 concrete having 0.5% Nano $CaC0_3$ content. At 14 and 28 days the maximum flexural strength is reported in the concrete containing 0.5% Nano $CaCO_3$ content.



Graph 2: Flexural strength of $CaCO_3$ at various dosages

Relation between Compressive and Flexural Strength

This is calculation is done from the experimented compressive strength values by using the formulae flexural strength = 0.7 (Compressive strength)$^{0.5}$

S. No.	Particulars	Calculated Flexural strength from compressive strength(MPa)	Experimental Values of flexural strength (MPa)
1	Control	3.60	7.12
2	T1	3.63	7.59
3	T2	3.95	8.09
4	T3	4.081	8.23
5	T4	4.234	8.57
6	C1	4.24	8.73
7	C2	4.17	8.17
8	C3	4.11	7.92
9	C4	3.96	7.26

4. Conclusion

Increasing the percentage of Nano TiO_2 leads to increase in flexural strength in concrete. The strength of concrete can also be increase by increasing the percentage beyond 2% of Nano TiO_2 content. With the increase of Nano $CaCO_3$ content in concrete the strength of the concrete is reduced. The optimum level of Nano $CaCO_3$ content is 0.5 %, further increment can be done by checking it I between 0.5% and 1% of Nano $CaCO_3$ Content.

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