Journal of Civil Engineering and Environmental Technology
p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 3, Issue 5; April-June, 2016, pp. 426-429

http://www.krishisanskriti.org/Publication.html

Effect on Compressive Strength of Concrete by Partial Replacement of Cement with Nano Titanium Dioxide and Nano Calcium Carbonate

Shivanshu Mishra[1] and Archana Tiwari[2]

[1]Student Department of Civil Engineering, Madhav Institute of Technology and Science Gwalior, India
[2]Department of Civil Engineering, Madhav Institute of Technology and Science Gwalior, India
E-mail: [1]shivanshumishra07@gmail.com, [2]archana62in@gmail.com

Abstract—*In this paper resulting change in the compressive strength of the concrete due to the partial replacement of cement by Nano-titanium di oxide and Nano-calcium carbonate are studied. Two types of concrete were prepared by replacing cement by Nano titanium dioxide and Nano calcium carbonate. Eight sets of specimens are casted and compared with the control specimen. In both types of concrete 0.5%, 1%, 1.5%, 2% by weight of cement is replaced by Nano material. In case of concrete prepared by using TiO_2 the maximum compressive strength is achieved at 2% replacement and in case of concrete prepared by using $CaCO_3$ the maximum strength is achieved at 0.5% replacement. As compared to the control concrete an increase of 38.5% is achieved in 28 days compressive strength in TiO_2 concrete and 38.4% in case of $CaCO_3$ concrete. The characteristic of the Nano-TiO_2 and Nano-$CaCO_3$ containing concrete is examined at the 7, 14, and 28 days*

1. INTRODUCTION

Concrete is the spine of the construction industry. The concrete in the pavement is subjected to various types of loads in a repeated form due to which various types of failure occurs in the concrete such as cracks due to over load and flexure. Flexural fatigue also responsible for failure of concrete pavement which can be reduced by use of nano material. Maximum improvement in flexural fatigue strength is reported best in concrete containing nano TiO_2 in amount of 1% by weight of binder[1].Most uniform dispersion of hydration products of cement is achieved at a small content of nano TiO_2, it accelerates the hydration at early age ages as indicated by heat of hydration [2].Cement replacement up to 20% by mixture of nano and micro $CaCO_3$ resulted in similar enhanced mechanical properties. Benefits of accelerated early age hydration through additional nucleation sites and enhanced particle packing density achieved [3]. Ali nazari reported decrease in setting time of cement mortar with increase in nano TiO_2 and improvement in flexural and tensile strength with the addition of Nano TiO_2 up to 1% at all ages of concrete [8,11]. Reduction in 28 days compressive strength of mortar is reported when TiO_2 increases. Inclusion of TiO_2 in cement mortar did not increase the 28 days compressive strength [10]. There are various nano materials available which are used frequently because of their dispersion quality such as carbon nano tubes(CNTs) and carbon nano fibers which provide reinforcement to the concrete and other particles 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. Small amount of TiO_2 results in effective increase in strength of the concrete thus it seems beneficial to use this material in the construction work by simply adding it in to the concrete. Nano calcium carbonate in the concrete can also be used similarly.

2. MATERIALS AND EXPERIMENTS

2.1 Materials

The materials used are given below.

Cement.

Portland Pozzolana Cement (prism) Fly ash based conforming to (IS: 1489-1991). The physical properties of cement were obtained by conducting appropriate tests.

Specific gravity is 2.9

Fineness- 2% retaining on 90 micron sieve

Coarse aggregate

Locally available 20 mm and 12.5mm size crushed granite with specific gravity 2.70 and water absorption 0.1%.

Fine aggregate

River sand was used and found to be Zone 2 with its specific gravity 2.60 and water absorption 1%.

Water

Water used was clean drinking fresh water (pH value 6-7) which is free from impurities and therefore, can be used for concrete mixing.

Nano Materials

Nano materials are purchased from Sakshi Dyes and Chemicals Delhi. Details are given table1

Table 1: Properties of nano materials

Property	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

3. SAMPLE PREPARATION AND FABRICATION

A total 3 sequence of specimens are prepared in the laboratory trails. First series consist of control mixture which was made of natural aggregates, cement and water. Series T is prepared with different dosage of titanium di oxide. The mixture was prepared with the cement replacement of 0.5%, 1%, 1.5% and 2% by weight. C series consist of different dosage of calcium carbonate. The mixture was prepared by replacing cement by calcium carbonate at 0.5%, 1%, 1.5% and 2% by weight. The water to binder ratio was taken 0.37 for all mixtures. Control mix(CO) is prepared by dry mixing of cement coarse aggregate and fine aggregate in drum mixer and then by adding water. Concrete produced is casted in cube mould of size 150mmx 150mmx150mm and then cubes are compacted on the vibrating table. After 24 hours cubes were demoulded and then cured. Series T is prepared by first dry mixing as for control specimen. TiO_2 is dissolved and stirred in water and added into drum mixer and is rotated for 2 to 3 minutes then the concrete obtained is casted in to the moulds of size 150mmx150mmx150mm and then compacted on the vibrating table. C series is prepared by dry mixing of cement, coarse and fine aggregate as prepared in the T series and calcium carbonate is added and properly stirred first in calculated quantity of water which is required for concrete and then this water is added to the drum mixture. Drum mixture is rotated for 2 to 3 minutes and mixture produced is casted in the mould and then cubes are compacted on the vibrating table. After demoulding cubes were cured.

Details of Sample

Details of the sample prepared are given in table2

Table 2: Quantities of material per cubic metre

Series	Sample name	Water (litres)	Cement (kg)	F.A. (kg)	CA (kg) 20mm 12.5mm	Nano TiO_2 (kg)	Nano $CaCO_3$ (kg)
Control mix	CO	186	502.70	567	639.06	426.04	----------
TiO_2	T1	186	500.18	567	639.06	426.04	2.51
	T2	186	497.66	567	639.06	426.04	5.02
	T3	186	495.15	567	639.06	426.04	7.54
	T4	186	492.63	567	639.06	426.04	10.05
$CaCO_3$	C1	186	500.18	567	639.06	426.04	---------- 2.51
	C2	186	497.66	567	639.06	426.04	---------- 5.02
	C3	186	495.15	567	639.06	426.04	---------- 7.54
	C4	186	492.63	567	639.06	426.04	---------- 10.05

Compressive strength of specimens at the different ages obtained by testing on compression 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 compressive stress for each type of concrete at different ages is reported.

4. COMPRESSIVE STRENGTH OF NANO TITANIUM DIOXIDE CONCRETE AND PERCENTAGE STRENGTH VARIATION FROM CONTROL CONCRETE ARE GIVEN IN TABLE NO.3

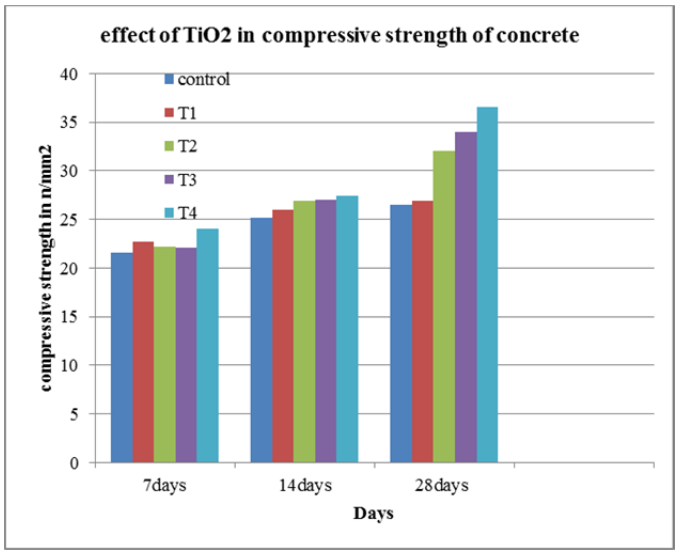
Table 3: Compressive strength of the control and TiO_2 blended cement concrete and percentage strength variation from control

Sample designation	Nano $TiO2$ particle (%)	7 days		14 days		28 days	
		Strength N/mm2	Percentage variation From control	Strength N/mm2	Percentage variation From control	Strength N/mm2	Percentage variation From control
Control	0	21.62	0	25.185	0	26.5	0
T1	0.5	22.72	5.08	26	3.23	26.9	1.5
T2	1	22.20	2.68	26.9	6.80	32	20.75
T3	1.5	22.1	2.22	27	7.20	34	28.30
T4	2	24	11	27.4	8.79	36.59	38.07

Water to binder [cement + Nano $TiO2$] ratio = 0.37

5. EXPERIMENTAL RESULT AND DISCUSSION

The 28 days compressive strength of the specimen increase with the increase in the percentage of Nano TiO_2 in concrete. For 0.5% TiO_2 concrete the 28 days compressive strength of the specimen is slightly more than the control specimen. for the concrete containing 1% of the TiO_2 the 7 days compressive strength increase is insignificant .but for 28 days strength of the TiO_2 concrete have increased significantly. For the concrete containing 1.5% of TiO_2 the 7 days strength of the concrete is not more than 1% TiO_2 concrete, but 28 days strength is more than concrete containing 1% TiO_2, the strength is 6 % more than 1% TiO_2 concrete . The concrete containing 2% TiO_2 gives maximum strength at all ages. This can be better understood by chart.



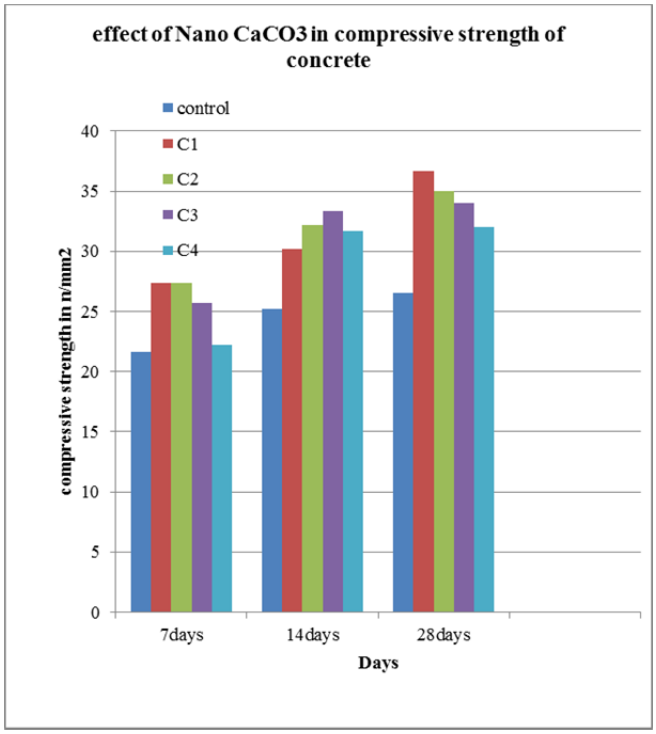
(1) Compressive strength of control and nano $CaCO_3$

The compressive strength of control and nano $CaCO_3$ is shown in the table comparison of the result for 7, 14 and 28 days done and shown in the table below

Table 4: Compressive strength of control and Nano $CaCO_3$ concrete and percentage strength variation from control concrete

Sample designation	Nano $CaCO$ 3 particle (%)	7 days		14 days		28 days	
		Strength N/mm2	Percentage variation From control	Strength N/mm2	Percentage variation From control	Strength N/mm2	Percentage variation From control
Control	0	21.62	0	25.18	0	26.50	0
C1	0.5	27.4	26.73	30.22	20.01	36.70	38.49
C2	1	27.4	26.73	32.20	27.87	35.51	32.07
C3	1.5	25.7	18.87	33	31.05	34.44	28.30
C4	2	22.2	2.68	31.70	25.89	32	20.75

The compressive strength of the control concrete specimen for comparison was same for TiO_2 and $CaCO_3$, therefore, as per the table 4 for 0.5% $CaCO_3$ concrete the strength is more than the control specimen for all 7 ,14 and 28 days. For 1% $CaCO_3$ concrete the strength is more than the control specimen, the strength at 7 and 14 days is more than the 0.5% $CaCO_3$ concrete but less than 0.5% $CaCO_3$ concrete at 28 days. For 1.5 % $CaCO_3$ concrete the strength is less than the 1% and 0.5% concrete, at 7 days but strength of the 1.5% $CaCO_3$ concrete, at 14 days is more than 0.5% and 1% and control concrete, at the 28 days strength is less than 0.5% $CaCO_3$ concrete and 1% $CaCO_3$ concrete. For 2% $CaCO_3$ concrete the strength is less than the 0.5%, 1% and 1.5% $CaCO_3$ concrete , strength is more than the control concrete for 7, 14 and 28 days except 0.5 $CaCO_3$ concrete at the curing age of 14 days. The variation is showed in graph below;



The strength in the case of nano calcium carbonate achieved is maximum at the dosage level of 0.5% at 28 days which is maximum above all the specimens in $CaCO_3$.

REFERENCES

[1] Li hui, Zhang Mao-hua, Ou Jin-ping., "Flexural fatigue performance of concrete containing nano-particles for pavement", International Journal of Fatigue 29 (2007) 1292-1301

[2] Xiao H., li Hui, Du Tao , li X, "Dispersion characteristic of nano-$T i O$ 2 in cement paste and its effect on the compressive strength and permeability', Nanotechnology in Construction,2015.

[3] Camiletti J., Soliman Ahmed, Nehdi Moncef L., "Effects of nano- and micro-limestone addition on early age propertes of ultra-high performance concrete",Materials and Structures(2013) 46:881-898.

[4] Mohamed Anwar M., "Influence of nano materials on flexural behaviour and compressive strength of concrete", HBRC Journal (2015), http://dx.doi.org/10.1016/j.hbrcj.2014.11.006.

[5] Shaikh Faiz U.A., Supit Steve W.M. , "Mechanical and durability properties of high volume fly ash (HVFA) concrete containg calcium carbonate ($CaCO$) nanoparticles", Construction and Building Materials 70(2014) 309-321.

[6] Nazari Ali, Riahi S.,,"The effects of SiO_2 nano particles on physical and mechanical properties of high strength compacting concrete", Composites: Part B 42 (2011) 570-578.

[7] Li hui, Zhang Mao-hua, Ou Jin-ping., "Abrasion resistance of concrete containing nano-particles for pavement", Wear 260 (2006) 1262-1266.

[8] Nazari Ali, Riahi S., shamekhi S, "Assessment of the effects of the cement paste composite in presence TiO 2 nanoparticles", Journal of American Science 2010;6 (4).

[9] Zhang Rui, Cheng Xin, Hou Pengkun, "Influences of nano-TiO 2 on the properties of cement-based materials; hydration and druing shrinkage", Construction and Building Materials 81 (2015) 35-41.

[10] Saliah S., Nor N., Jamaludin M., "The effects of TiO 2 in the performance of mortar", International Integrated Engineering Summit (2014).

[11] Nazari Ali, Riahi S., shamekhi S, "Improvement in the mechanical properties of the cementitious composite by using TiO 2 nanoparticles, Journal of American science, 2010;6(4).