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EFFECT OF NANO TITANIUM DIOXIDE AND M-SAND IN SELF CURING CONCRETE

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ABSTRACT - *The development of self curing concrete has brought about the essential need in place of water scarcity and also the application of nanotechnology in concrete has added a new dimension to the efforts to improve its properties. Nano materials, by virtue of their very small particle size can affect the concrete properties by altering the micro structure. In this project, an attempt is made to use the anatase based nano titanium dioxide (Tio_2) of size 15 nanometer (nm) was used to improve the compressive strength. Nano Tio_2 is replaced with cement in the proportions of 0.5% and 1% by weight of cement. M sand is completely used instead of river sand. The Mix design adopted is M25 grade. Self curing agent used is poly-ethylene glycol (PEG) with a molecular weight of 600 (PEG 600). This PEG 600 is added in proportions of 0.5%, 1%, 1.5%, 2% and 2.5% by weight of cement. For all the specimens (Self curing concrete and Conventional concrete) only compression strength is tested after 28 days of curing. Then the result is compared with Self curing concrete specimens and Conventional concrete specimens. The experimental result shows that self curing concrete cube specimens made with replacement of 1% of nano titanium dioxide, 1% PEG 600 (by weight of cement) and M-Sand gives highest compressive strength (38.75 N/mm^2) after 28 days of self curing when compared to conventional concrete cube specimens and any other types of self curing concrete cubes specimens and also all self curing concrete cube specimens gives high compressive strength when compared to conventional concrete cube specimens.*

***Key Words*: Nano Titanium dioxide, Polyethylene glycol, M-sand, compressive strength**

1. INTRODUCTION

1.1. Self curing concrete:

Proper curing of structures is important to meet the performance and durability requirements. Self curing concrete is a type of concrete which is cured by itself without any use of external curing methods.

Self curing or internal curing is a technique that can be used to provide additional moisture in concrete for more effective hydration of cement. This self curing concrete is used in water scarcity area, where the demand of water is high and application of water curing is not possible for some reasons of economy. Since, in internal curing there is a chance of atmospheric effect and also hydration process is not completely eliminated and this may affect the concrete strength and other parameters. Hence, to make internal curing a successful process, water soluble polymers is used along with concrete. This usage of water soluble polymers imparts strength in self curing concrete but with some dosage.

1.2 NANO TITANIUM DIOXIDE:

Nano materials (Nano Titanium Dioxide) are very small sized materials with particle size in nanometers (nm). These materials are very effective in changing the properties of concrete at the ultrafine level by the virtue of their very small size. The small size of the particles also means a greater surface area. Only a small percentage of cement can be replaced to achieve the desired results. These nano materials improve the strength and permeability of concrete by filling up the minute voids and pores in the microstructure. The use of nano titanium dioxide (TiO_2) in concrete mix in previous studies has shown results of increase in the compressive and tensile strength of concrete. Nano titanium dioxide mixed with cement can generate nano-crystals of C-S-H (Calcium silicate hydrate) gel after hydration. This C-S-H does not have a definite structure and it is so called as gel. This C-S-H is the main product of hydration of Portland cement and it is primarily responsible for the strength in cement based materials. These nano-crystals accommodate in the micro pores of the cement concrete, hence improving the permeability and strength of concrete. The properties of Nano titanium dioxide used in this project are shown in table 1.

Table 1: Properties of Nano Titanium dioxide

Specific gravity	3.7
Particulars	Anatase based
pH content	7.4
Colour	White
Particle size (nanometer)	15
Oil absorption %	15 to 30%
Moisture content	0.50% max
Density (Kg/m^3)	3.76
Iron (PPM)	112
Poisson's ratio	0.27

1.2 POLY ETHYLENE GLYCOL:

In this project, Poly-ethylene glycol with a molecular weight of 600 (PEG 600) was used as a self curing agent. Poly-Ethylene Glycol 600 is a condensation polymer of ethylene oxide and water with the general chemical formula HO $(C_2H_4O)_nH$. One common feature of PEG appears to be the water soluble nature and hence this PEG 600 is directly added to the water. This PEG 600 is always added to the water and stirred for some time with glass rod without any air bubbles and then only added to the concrete.

Table 2: Details of PEG 600 used in this project

Average Molecular weight	570 to 630
Weight per ml at 20˚C	1.126 to 1.128 grams
Viscosity at 100˚C	9.9 to 11.2 Centistokes
Freezing point	~ 20˚C
Hydroxyl number	178 to 197
Water	0.5% max

2. EXPERIMENTAL STUDY

2.1. Materials Used:

a) Ordinary Portland cement (OPC):

In this project, Ordinary Portland Cement of 53 grade conforming to IS 12269-1987 was used with a specific gravity of 3.15.

b) Fine Aggregate (F.A):

In this project, natural sand (resulting from natural disintegration of rocks) is used as fine aggregate confirming to IS 383-1970. In this project, natural sand is used only for making of conventional concrete cube only and this conventional concrete cube is cured by external curing methods.

c) Manufactured Sand (M-sand):

M-Sand stands for Manufactured Sand. M-sand is crushed aggregates produced from hard granite stone which is cubically shaped with grounded edges, washed and graded is also identified as a good alternative fine aggregate to river sand. In this project, M-sand is replaced completely by natural sand for making of self curing concrete cubes.

Fig -1: M-Sand

d) Coarse Aggregate (C.A)

Crushed stones obtained from local quarries were used as coarse aggregate. Crushed angular coarse aggregates of 20mm nominal sizes are used as per IS 383-1970.

e) Nano Titanium dioxide (Tio_2):

As described previously, anatase based Nano titanium dioxide of size 15 nanometer was used to improve the compressive strength of self curing concrete cubes. This Nano Tio_2 is replaced with cement in the proportions of 0.5% and 1% by weight of cement only for making of self curing concrete cubes.

f) Polyethylene Glycol (PEG 600):

As described previously, PEG 600 was used as a self curing agent for making of self curing concrete cubes. This PEG 600 was added in proportions of 0.5%, 1%, 1.5%, 2% and 2.5% by weight of cement.

Fig -2: PEG

e) Water:

Portable water free from salts was used for casting and curing of concrete with pH value of 6 to 7.

2.2 Material Testing results:

The basic materials used for making of conventional concrete cube and self curing concrete cube was tested in

laboratory and the material testing results for each of the basic materials was shown in table 3.

Table 3: Material testing results

S.NO	NAME OF THE TEST	VALUE OF THE TEST
1	Fineness test of cement as per IS 12269-1987	10%
2	Specific gravity of cement as per IS 2386 (part II)	3.15
3	Fineness modulus of river sand	4.39
4	Specific gravity of river sand as per IS 2386: 1963 part 3	2.57
5	Bulk density of river sand	220 kg/m^3
6	Void ratio of river sand	10.325
7	Water absorption of river sand	1.47%
8	Fineness modulus of M-sand	5.6
9	Specific gravity of M-sand	2.84
10	Bulk density of M-sand	230 kg/m^3
11	Void ratio of M-sand	11.76
12	Specific gravity of Coarse aggregate	2.68
13	Bulk density of coarse aggregate	330 kg/m^3
14	Water absorption test on coarse aggregate	1.25%
15	Impact test on coarse aggregate	18.5%

2.3 Mix Design:

In this project, mix design adopted was M25. The concrete proportions arrived by using M25 grade concrete as per IS 10262:2009 was 1:1.48:1.97 (Cement: Fine aggregate: Coarse aggregate)

2.4 Fresh Concrete Test:

In this project, slump cone test is carried out for different water-cement ratio and the values of slump for each water-cement ratio were tabulated as shown in table 4.

Volume of slump cone = 0.005495m^3
Density = Mass / Volume
2400 kg / m^3 = Mass / Volume
Mass = (2400 kg / m^3) × (volume)
Mass = 2400 × 0.005495
Mass = 13.188 kg
Adopt wastage = 5% of mass
Final mass including wastage = 15 kg of concrete
Sum of concrete = (Cement + F.A + C.A)
Sum of concrete = (1+ 1.48+1.97) = 4.45 kg

Mass of cement = (1 / 4.45) × 15 = 3.370 kg
Mass of F.A = (1.48 / 4.45) × 15 = 4.98 kg
Mass of C.A = (1.97 / 4.45) × 15 = 6.640 kg

Table 4 – Values of slump for different water cement ratio

S.NO	Water-cement ratio	Amount of water in mL	Slump height in mm
1	0.40	1348	20
2	0.50	1686	60
3	0.60	2022	150

Fig -3: Slump Cone Test

2.4 Casting, curing and batching of concrete cube specimens:

Concrete cube of size 150mm×150mm×150mm was used for testing of M25 grade concrete at 28 days for both conventional concrete and self curing concrete. All the specimens were kept at room temperature after demoulding of concrete cubes. The details of all the concrete cube specimens were shown in table 5 to table 15.

Fig -4: Casting of specimen

Fig -5: Concrete cube specimen

Table 5 – Details of Conventional concrete cube (C1)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)
1.743	2.583	3.430	700

Table 6 – Details of Self curing concrete cube (SC1)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	0.5% PEG 600 (mL)	0.5% Nano Tio_2 (grams)
1.733	2.583	3.430	700	8	10

Table 7 – Details of Self curing concrete cube (SC2)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	1% PEG 600 (mL)	0.5% Nano Tio_2 (grams)
1.733	2.583	3.430	700	17	10

Table 8 – Details of Self curing concrete cube (SC3)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	1.5% PEG 600 (mL)	0.5% Nano Tio_2 (grams)
1.733	2.583	3.430	700	25	10

Table 9 – Details of Self curing concrete cube (SC4)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	2% PEG 600 (mL)	0.5% Nano Tio_2 (grams)
1.733	2.583	3.430	700	34	10

Table 10 – Details of Self curing concrete cube (SC5)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	2.5% PEG 600 (mL)	0.5% Nano Tio_2 (grams)
1.733	2.583	3.430	700	43	10

Table 11 – Details of Self curing concrete cube (SC6)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	0.5% PEG 600 (mL)	1% Nano Tio_2 (grams)
1.723	2.583	3.430	700	8	20

Table 12 – Details of Self curing concrete cube (SC7)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	1% PEG 600 (mL)	1% Nano Tio_2 (grams)
1.723	2.583	3.430	700	17	20

Table 13 – Details of Self curing concrete cube (SC8)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	1.5% PEG 600 (mL)	1% Nano Tio_2 (grams)
1.723	2.583	3.430	700	25	20

Table 14 – Details of Self curing concrete cube (SC9)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	2% PEG 600 (mL)	1% Nano Tio_2 (grams)
1.723	2.583	3.430	700	34	20

Table 15 – Details of Self curing concrete cube (SC10)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	2.5% PEG 600 (mL)	1% Nano Tio_2 (grams)
1.723	2.583	3.430	700	43	20

2.5. Compressive Strength of concrete:

One of the most important properties of the hardened concrete is its strength which represents the ability if concrete to resists forces. Of the various strengths of concrete, the determination of compressive strength has receives a large amount of attention, because the concrete is primarily meant to withstand compressive strength or in other words, concrete is strong in compression and weak in tension. Hence the value of tension for concrete is neglected. The compressive strength of concrete is defined as the load which causes the failure of specimen, per unit area of cross section under given rate of loading. The compressive strength of concrete is expressed as N/mm^2. The compressive strength at 28 days of curing (any type of curing methods) is taken as a criterion for specifying the quality of concrete. This is termed as grade of concrete. IS 456-2000 stipulates the use of 150mm cubes.

Compression strength = (Load at failure (or) Load at final crack) /(Area of compression face) in (N/mm^2).

Fig -6: compression Testing of Concrete cube specimen

3. RESULTS AND DISCUSSIONS

The results of mechanical strength properties such as compressive strength corresponding to Nano TiO_2 dosage, PEG 600 dosage of the different concrete cube specimens has been thoroughly studied and comparison of Nano TiO_2, PEG 600 and M-Sand influenced concrete cube specimens (self curing concrete cube specimens) with conventional concrete specimens were made and compared. Since the main focus of this project is to utilize effect of the Nano titanium dioxide, PEG 600 and M-sand to attain maximum strength, the results obtained from the compression strength test are briefly discussed in this chapter. The values of compressive strength for both conventional and self curing concrete cubes were shown in table 16.

Table 16 – Compressive strength results at 28 days for M-25 grade concrete

Cube Name	Load at Final Crack (KN)	Area of cube (mm^2)	Compressive strength (N/mm^2)
C1	750	150×150	33.33
SC1	834	150×150	37.06
SC2	842	150×150	37.42
SC3	808	150×150	35.91
SC4	796	150×150	35.37
SC5	785	150×150	34.88
SC6	860	150×150	38.22
SC7	872	150×150	38.75
SC8	866	150×150	38.48
SC9	854	150×150	37.95
SC10	846	150×150	37.60

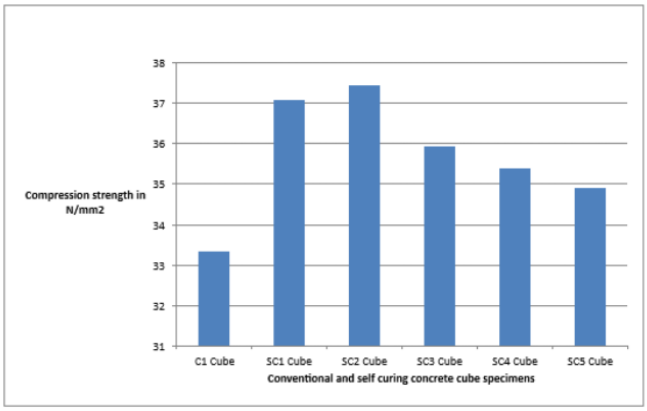

Chart -1: Compression strength values for conventional Concrete cube (C1) VS Self curing concrete cubes (SC1, SC2, SC3, SC4 & SC5)

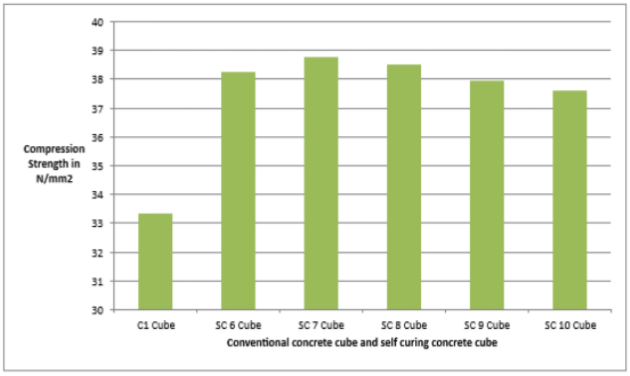

Chart - 2: Compression strength values for conventional Concrete cube (C1) VS Self curing concrete cubes (SC6, SC7,SC8, SC9, SC10)

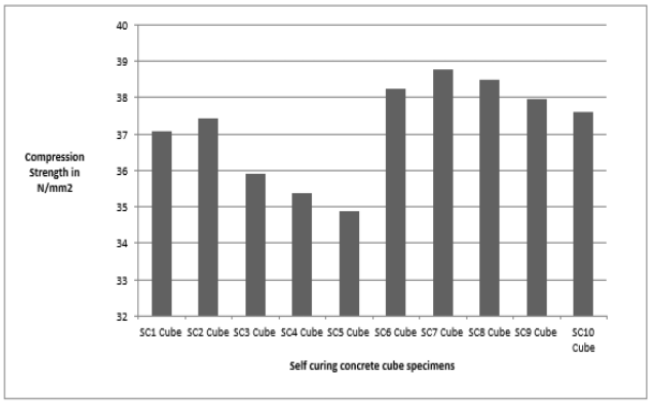

Chart 3 - Compression strength values for all Self curing Concrete cubes

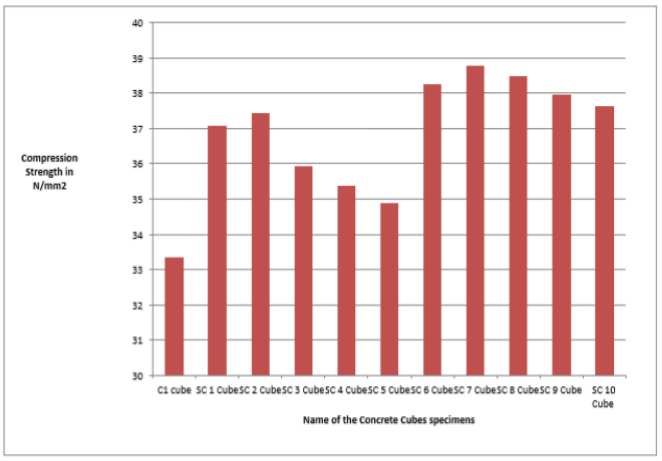

Chart 4 – Compression strength values for all concrete Cube specimens

4. CONCLUSIONS:

i) From the experimental results, self curing concrete cube specimens made with replacement of 1% of nano titanium di-oxide, 1% PEG 600 (by weight of cement) and M-Sand

gives highest compressive strength (SC 7 Cube – 38.75 N/mm^2) after 28 days of self curing when compared to conventional concrete cube specimens (C1 cube) and any other types of self curing concrete cubes specimens.

ii) Self curing concrete cube specimens made with replacement of 1% of nano titanium di-oxide (by weight of cement) along with addition of different proportions of PEG 600 (0.5%, 1%, 1.5%, 2% and 2.5% by weight of cement – SC 6 Cube, SC 7 Cube, SC 8 Cube, SC 9 Cube and SC 10 Cube) gives higher compressive strength when compared to conventional concrete cube specimens.

iii) Self curing concrete cube specimens made with replacement of 1% of nano titanium dioxide (by weight of cement) along with addition of different proportions of PEG 600 (0.5%, 1%, 1.5%, 2% and 2.5% by weight of cement – SC 6 Cube, SC 7 Cube, SC 8 Cube, SC 9 Cube, SC 10 Cube) gives higher compressive strength when compared to other self curing concrete specimens (SC 1 Cube, SC 2 Cube, SC 3 Cube, SC 4 Cube and SC 5 cube).

iv) All Self curing concrete cube specimens gives high compressive strength when compared to conventional concrete cube specimens.

v) Self curing concrete cube specimens made with replacement of 0.5% of nano titanium dioxide (by weight of cement) along with addition of 1% PEG 600 (by weight of cement – SC 2 Cube – 37.42 N/mm^2) gives higher compressive strength when compared to other self curing concrete specimens (SC 1 Cube, SC 3 Cube, SC 4 Cube, SC 5 Cube) and conventional concrete cube specimen (C1).

vi) Finally, use of both nano particles (nano titanium dioxide) and PEG 600 imparts greater compressive strength in self curing concrete

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