REPLACEMENT OF CEMENT BY USING NANO TITANIUM DIOXIDE AND BLACK CARBON POWDER IN HIGH STRENGTH CONCRETE

L.SRIKANTHAN[1], S.MAHESWARI[2], S.FELIX FRANKLIN[3], V.ANTONY FRANCIS[4], R.ARVIND SARAVAN[5]

[1]Assistant professor, Department of civil Engineering, ARM College of Engineering and technology, sattamangalam, Maraimalai nagar, Tamilnadu-603209
[2,4,5]Assistant professor, Department of civil Engineering, Mohamed Sathak A.J.College of Engineering, Siruseri, Old Mahabalipuram, Chennai, Tamilnadu - 603103
[3]Assistant professor, Department of civil Engineering, Vi Institute of Technology, Sirunkundram – 603108

ABSTRACT - *The development of high strength concrete using nano materials have been achieved in various research projects and also the involvement of mineral admixture imparts high strength to the concrete. In this project, an attempt is made to use both the anatase based nano titanium dioxide (Tio_2) of size 15 nanometer (nm), Black carbon powder (mineral admixture)and Dewflo SP101 (High range water reducing admixture with workability retention properties) was used to improve the compressive strength of concrete. Nano Tio_2 is replaced with cement in the proportions of 0.5% and 1%, 1.5% and 2% by weight of cement. Black carbon powder (Mineral Admixture) is replaced with cement in the proportions of 5%, 10%, 15%, 20%, 25% and 30% and the dosage of Dewflo SP101 adopted was 0.7% by weight of cement proportions. For all the concrete specimens (Conventional concrete and concrete made with replacement material) only compression strength is tested after 28 days of external curing. Then the result is compared with Conventional concrete specimens and concrete made with replacement material. The experimental result shows that the concrete cube specimens made with replacement material of 1% Nano titanium dioxide by weight of cement and 0.7% of dewflo SP 101 admixture by weight of cement) gives highest compressive strength (44.09 N/mm²) after 28 days of curing when compared to conventional concrete cube specimens (38.31 N/mm²) and also the concrete cube specimens made with replacement material of 5% Black carbon powder by weight of cement and 0.7% of dewflo SP 101 admixture by weight of cement) also gives highest compressive strength (40.84 N/mm²) after 28 days of curing when compared to conventional concrete cube specimens (38.31 N/mm². Finally the use of both nano titanium dioxide, black carbon powder and dewflo SP 101 admixture gives higher compressive strength*

Key Words: **Nano Titanium dioxide, Black carbon powder, Dewflo SP 101**

1. INTRODUCTION

1.1 High strength concrete:

High strength concrete is a type of concrete that must contains compressive strength greater than 40N/mm². High strength concrete is made by lowering the water cement ratio to 0.35 or lower. In high strength concrete, the aggregate plays an important role on the strength of concrete and also in order to obtain high strength concrete along with good workability it is necessary to study carefully the cement composition and fineness. Low water to cement ratio in high strength concrete causes densification in both the matrix and interfacial transition zone and the aggregate may become the weak link in the development of mechanical strength and hence the use of water reducers, retarders, high range water reducers or superplasticiser is mandatory for achieving high strength concrete.

1.2 Nano Titanium Dioxide:

Nano materials (Nano Titanium Dioxide) are very small sized materials with particle size in nanometers (nm). Nanotechnology concerns with the usage of materials falling in range of few to less than 100 nanometers. When nano Titanium Dioxide (TiO_2) with the average particle size of 15 nanometer (nm) were added to concrete, physical and mechanical properties of the specimens were measured. Nano TiO_2 particle as a replacement of cement (upto 2% weight of cement proportions in concrete) could accelerate C-S-H gel formation as a result of increased crystalline $Ca(OH)_2$ amount at the early age of hydration and hence increase compressive strength and split tensile strength of concrete. These nano particles help in 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/m³)	3.76
Iron (PPM)	112
Poisson's ratio	0.27

1.3 Black Carbon Powder:

Carbon black powder (sub types are acetylene black, channel black, lamp black and thermal black) is a material produced by the incomplete combustion of heavy petroleum products such as FCC tar, coal tar, ethylene-cracking tar, and a small amount from vegetable oil. In plastics, paints, and inks carbon black is used as a colour pigment. Carbon black is virtually pure elemental carbon in the form of colloidal particles that are produced by incomplete combustion or thermal decomposition of gaseous or liquid hydrocarbons under controlled conditions. Its physical appearance is that of a black, finely divided pellet or powder. It is a waste from rubber industry and also finds difficulty in disposal. Normally these rubber wastes are dumped into soil creating soil pollution and contamination of water table. By using carbon black powder as filler in concrete we can reduce this problem to a great extent. There by re using the waste usefully and making it eco-friendly to environment. Details of Black carbon powder used in this project are given in table 2.

Table 2: Details of Black carbon powder

Specific gravity	1.33
pH	6
Carbon (C)	82.54%
Iron (Fe)	0.160%
Sulphur (S)	1.578%
Ash	1.68%

1.4 Dewflo SP 101:

Dewflo SP101 is not classified as hazardous material and also Dewflo SP 101 is non flammable. Dewflo SP101 is formulated from selected polymers specially designed to enable the water content of the concrete to perform more effectively. This effect can be used to improve workability, to increase ultimate strengths or to facilitate a reduction in the cement content while sustaining mix properties. Dewflo SP101 has strong workability retention which helps in long distance and hot weather concrete deliveries, and is particularly suitable for ready-mix concrete. Dewflo SP 101 has also has the ability to produce high quality concrete of improved durability and water tightness. Dewflo SP101 can be used with all types of Portland cement and cement replacement materials.

Dewflo SP101 is compatible with other Dewbond admixtures used in the same concrete mix. Dewflo SP101 should be added to the concrete with the mixing water to achieve optimum performance. The properties of dewflo SP 101 admixture are shown in table 3.

Table 3: Properties of Dewflo SP 101 admixture

Colour	Brown liquid
Specific Gravity	1.19±0.02 @ 27°C
Chloride content	Nil
Air entrainment	Typically less than 1%

2. EXPERIMENTAL STUDY

2.1. Materials Used:

a) Ordinary Portland cement (OPC):

In this project, Ordinary Portland Cement of 43 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, only natural sand is used for making of both conventional concrete cube and concrete made with replacement material. No alternative material is replaced with natural sand in this project.

c) 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.

d) 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%, 1.5% and 2% by weight of cement only for making of concrete cube with replacement materials.

Fig 1 – Nano Titanium Dioxide

e) Black Carbon Powder:

As described previously, Black carbon powder was used as a mineral admixture. The proportions of Black carbon powder adopted in this project was 5%, 10%, 15%, 20% 25% and 30% by weight of cement proportions and was added to the concrete made with replacement materials.

Fig 2 – Black carbon powder

f) 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 concrete cube made with replacement materials cube tested in laboratory and the material testing results for each of the basic materials was shown in table 3.

Table 4: 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	3.55
4	Specific gravity of river sand as per IS 2386: 1963 part 3	2.47
5	Water absorption of river sand	1%
6	Sieve Analysis of coarse aggregate	4.355
7	Specific gravity of Coarse aggregate	2.92
8	Water absorption test on coarse aggregate	2%
9	Impact test on coarse aggregate	12.5%

2.3 Mix Design:

In this project, mix design adopted was M30. The concrete proportions arrived by using M30 grade concrete as per IS 10262:2009 was 1:1.56:4.98 (Cement: Fine aggregate: Coarse aggregate)

2.4 Casting, curing and batching of concrete cube specimens:

Concrete cube of size 150mm×150mm×150mm was used for testing of M30 grade concrete at 28 days for both conventional concrete and concrete cube made with replacement materials. 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 3 – Casting of concrete specimens

Table 5 – Details of Conventional concrete cube (C1)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)
1.650	2.579	6.170	490

Table 6 – Details of replacement concrete cube (AS1)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	0.7% Dewflo SP 101 (mL)	0.5% Nano TiO_2 (grams)
1.640	2.579	6.170	490	10	10

Table 7 – Details of replacement concrete cube (AS2)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	0.7% Dewflo SP 101 (mL)	1% Nano Tio$_2$ (grams)
1.632	2.579	6.170	490	12	16

Table 8 – Details of replacement concrete cube (AS3)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	0.7% Dewflo SP 101 (mL)	1.5% Nano Tio$_2$ (grams)
1.625	2.579	6.170	490	12	25

Table 9 – Details of replacement concrete cube (AS4)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	0.7% Dewflo SP 101 (mL)	2% Nano Tio$_2$ (grams)
1.615	2.579	6.170	490	10	35

Table 10 – Details of replacement concrete cube (AS5)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	5% Black Carbon powder (grams)	0.7% Dewflo SP 101 (mL)
1.570	2.579	6.170	490	80	10

Table 11 – Details of replacement concrete cube (AS6)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	10% Black Carbon powder (grams)	0.7% Dewflo SP 101 (mL)
1.485	2.579	6.170	490	165	10

Table 12 – Details of replacement concrete cube (AS7)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	15% Black Carbon powder (grams)	0.7% Dewflo SP 101 (mL)
1.400	2.579	6.170	490	250	10

Table 13 – Details of replacement concrete cube (AS8)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	20% Black Carbon powder (grams)	0.7% Dewflo SP 101 (mL)
1.320	2.579	6.170	490	330	10

Table 14 – Details of replacement concrete cube (AS9)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	25% Black Carbon powder (grams)	0.7% Dewflo SP 101 (mL)
1.240	2.579	6.170	490	410	10

Table 15 – Details of replacement concrete cube (AS10)

Cement (kg)	F.A (kg)	C.A (kg)	Water (mL)	30% Black Carbon powder (grams)	0.7% Dewflo SP 101 (mL)
1.150	2.579	6.170	490	500	10

2.5. Compressive Strength of concrete:

The compressive strength of concrete place an important role in the field of civil engineering and desired compressive strength is essential to achieve the goal of success for the purpose of the construction meant and also to achieve the life period of structure.

Hence the testing of compressive strength of concrete is essentially important. 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/mm²).

Fig 4 - 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, Black carbon dosage, Dewflo SP 101 admixture dosage of the different concrete cube specimens has been thoroughly studied and comparison of concrete cube made with Nano TiO_2 proportions, Black carbon proportions and dewflo SP 101 admixture dosage were compared with conventional concrete specimens. Since the main focus of this project is to utilize effect of the Nano titanium dioxide, Black carbon powder and dewflo SP 101 admixture 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 concrete cube (C1) and concrete cube made with replacement materials (AS 1 to AS 10) were shown in table 16.

Table 16 – Compressive strength results at 28 days for M-30 grade concrete for all concrete cube specimens

Cube Name	Load at Final Crack (KN)	Area of cube (mm²)	Compressive strength (N/mm²)
C1	862	150×150	38.31
AS 1	741	150×150	32.93
AS 2	992	150×150	44.09
AS 3	762	150×150	33.87
AS 4	842	150×150	37.42
AS 5	919	150×150	40.84
AS 6	732	150×150	32.53
AS 7	728	150×150	32.36
AS 8	722	150×150	32.08
AS 9	709	150×150	31.51
AS 10	714	150×150	31.73

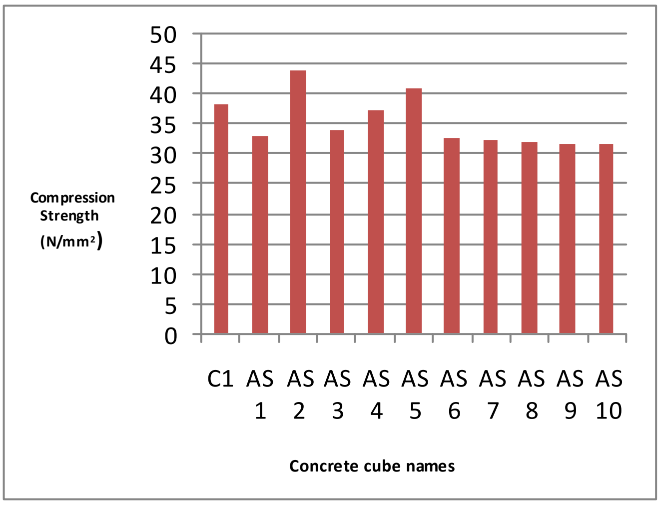

Chart -1: Compression strength (N/mm²) values for all concrete cube specimens

4. CONCLUSIONS:

i) From the experimental results, concrete cube specimens made with replacement of 1% of nano titanium di-oxide, 0.7% Dewflo SP 101 admixture (by weight of cement) gives highest compressive strength (AS 2 Cube – 44.09 N/mm²) after 28 days of curing when compared to conventional concrete cube specimens (C1 cube – 38.31 N/mm²) and also this AS 2 cube only has the highest compressive strength among all the concrete cube

ii) From the experimental results, concrete cube specimens made with replacement of 5% of black carbon powder, 0.7% Dewflo SP 101 admixture (by weight of cement) gives higher compressive strength (AS 5 Cube – 40.84 N/mm²) after 28 days of curing when compared to conventional concrete cube specimens (C1 cube – 38.31 N/mm²)

iii) Hence the influence of both nano titanium dioxide of size 15 nanometer, black carbon powder (mineral admixture) and dewflo SP 101 admixtures imparts high strength in concrete

REFERENCES

[1] L.Srikanthan, J. Bhuvanesh, M.Deepa, E.Rathna "Effect of Nano Titanium Dioxide and M-sand in self curing concrete" volume 5, issue 4, 2018, International research of engineering and technology, page 559 to 564

[2] L.Srikanthan, S. Felix Franklin, A.P. Iyappan, J.Bhuvaneswari, A. Preethika "Replacement of cement

by using Nano titanium dioxide in concrete, volume 5, issue 7, 2017, International journal for scientific research and development, page 499 to 503

[3] B.Padmapriya, Mrs.K.Pandeeswari "Experimental Inverstigation On The Properties Of Concrete With Carbon Black" volume 4, issue 4, 2016, International journal of advanced research, Page 1082 to1088

[4] Kifayah Abbood Alsaffar "Review of the Use of Nanotechnology in Construction Industry", volume 10, issue 8, 2014, International Journal of Engineering Research and Development, page 67-70

[5] M.V. Jagannadha Kumar, M. Srikanth, K. Jagannadha Rao. "Strength Characteristics of Self-Curing Concrete", volume 1, issue 1, 2012, International journal of research in engineering and technology, page 51 to 57

[6] Z.colleparadi, R. Kamran, F. Mohammad, G. Ahmad, and F. Hosein. "Effect of Combination of Silica Fume, Fly Ash and Ultrafine Amorphous Colloidal Silica (UFACS) On Concrete", IJCEE: International Journal of Civil & Environmental Engineering, volume 12, 2010, page 53-59.

[7] Aiswarya. S "An Experimental Investigation on Concrete By Using Nano Metakaolin" Research Journal of Recent Sciences Volume 2, 2014, page 17- 24

[8] K. Bala Subramanian, A. Siva, S. Swaminathan, M. Arul. G. Ajin "Development of High Strength Self Curing Concrete Using Super Absorbing Polymer", volume 9, issue 12, 2015, International journal of civil and environmental engineering

[9] IS 10262: 2009 "Concrete Mix Proportioning"

[10] IS 456: 2000 "Plain and Reinforced Concrete – code of Practice" Bureau of Indian Standards, New Delhi

[11] IS 2386 Part I 1963 "Methods of Test for Aggregate for Concrete"

[12] IS:383-1970: Specification for coarse and fine aggregates From natural sources for concrete, Bureau of Indian Standards, New Delhi,1993.

[13] ACI Committee 211.4R.93, "Guide for Selecting properties for High Strength Concrete with Portland Cement and Fly ash" ACI manual of concrete Practice, 2001.

[14] Gopalakrishnan.S, "Effect of partial replacement of cement with fly ash on the strength and durability of HPC". The Indian Concrete Journal, 2001, page 335 - 341.

[15] IS methods of tests for strength of concrete, IS 516: 1959, Bureau of Indian Standards, New Delhi.