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An Experimental Investigation on High-Performance Self Compacting Concrete Using Nano Technology for Modern Infrastructure Development

Ch. Naveen Kumar[1], B. Pavan Kumar[2], B. Abhilash[3]

[1]*UG Student, Department of Civil Engineering, VNR Vignana Jyothi Institute of Engineering and Technology*
[2]*UG Student, Department of Civil Engineering, VNR Vignana Jyothi Institute of Engineering and Technology*
[3]*UG Student, Department of Civil Engineering, VNR Vignana Jyothi Institute of Engineering and Technology*

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Abstract – *High strength self-compacting concrete (HSSCC) is the advanced engineered material in rapid fast growing infrastructure development. There are different ways to produce HSSCC, one of the finest methods among them is by improving the micro-structure of cement using Nano materials in Concrete. Now-a-days, application of Nano materials has received prominent attention to enhance the self-compacting concrete properties. Nano materials in concrete helps to increase its strength and performance properties. Nano materials in concrete helps to increase helps to increase its strength and performance properties. Nano materials are defined as the materials that contain particle size less than 200nm. Some of the Nano materials are Nano silica, Nano alumina, Graphene oxide and Carbon nano tubes, etc. The main aim of this study is to know the effect of Fresh Properties in addition of Nano Silica and Nano alumina in High Strength Self Compacting Concrete. Further this study is to investigate the micro-structure and hardened properties of Nano alumina and Nano silica incorporated in High Strength Self Compacting Concrete. Silica fumes are used for better dispersion of Nano Materials in the concrete.*

***Key Words*: High Strength Self Compacting Concrete, Nano Silica, Nano alumina, Graphene oxide, GGBS**

1. INTRODUCTION

High Performance Self-Compacting Concrete (HPSCC) is a revolutionary kind of concrete that has sparked a lot of interest. The benefits of HPSCC to the building industry are numerous: the removal of compaction work reduces placement costs, construction equipment requirements, construction time, and improves quality control. Nanotechnology has the ability to revolutionize the field of concrete materials science, according to most experts. The fundamental processes that regulate the most important aspects of concrete technology (strength, ductility, early age rheology, creep and shrinkage, fracture activity, longevity, and so on) are all influenced, if not completely governed, by the material's efficiency at the nano scale. However, there is a lack of clarity about how to conduct realistic materials science study at the nanoscale, how to increase the material's value, and how to evolve and commercialize these nanoscale concepts. Having well-defined priorities in the pursuit of nanotechnology in concrete materials science can be extremely beneficial to the scientific community. Having well-defined priorities in the pursuit of nanotechnology in concrete materials science can be extremely beneficial to the scientific community. Concrete is difficult to alter at the nanoscale for much of the same reasons that make it such an attractive construction material. The addition of nanoscaled materials to the Portland cement framework will alter the material's properties. Nano silica (nano-$SiO2$) is a synthetic substance made up of spherical particles from 1 to 50 nanometers in diameter. Nano silica decreases the porosity of hydrated cement paste by filling the voids left in the gaps between larger particles (fly ash and cement grains) at the nano scale, similar to silica fume on the micro scale.

2. MATERIALS USED

To make a High-Performance Self Compacting Concrete, the material required are follows:

1.	BINDER	:	Cement & GGBS
2.	FINE AGGREGATE	:	River Sand
3.	COARSE AGGREGATE	:	Gravel
4.	HARDENER	:	Water

5.	SUPER PLASTICIZER	:	Master Glenium ACE 30
6.	ADDITIVE	:	Graphene Oxide

3. MIX PROPORTION

Table-1: Materials and quantities

MATERIALS	QUANTITY
W/C	0.34
Cement	315 kg/m^3
GGBS	135 kg/m^3
Fine Aggregate	1000 kg/m^3
Coarse Aggregate	857 kg/m^3
Water	153 kg/m^3
Super Plasticizer	2.745 kg/m^3
Graphene Oxide	0%, 0.01%, 0.03%, 0.05% to the weight of content

Table- 2: Mix & its Proportions

TRIAL	PARTICULARS
MIX 1	M60 grade concrete + 0 % of graphene oxide to the weight of cement
MIX 2	M60 grade concrete + 0.01 % of graphene oxide to the weight of cement
MIX 3	M60 grade concrete + 0.03 % of graphene oxide to the weight of cement
MIX 4	M60 grade concrete + 0.05 % of graphene oxide to the weight of cement
MIX 5	M60 grade concrete + 0.05 % of graphene oxide to the weight of cement

4. TESTS

4.1 Workability Tests

4.1.1 Slump Flow Test

The slump flow test is performed to check the filling ability of concrete by measuring the average diameter of concrete circle formed when the slump is allowed to flow freely in horizontal direction.

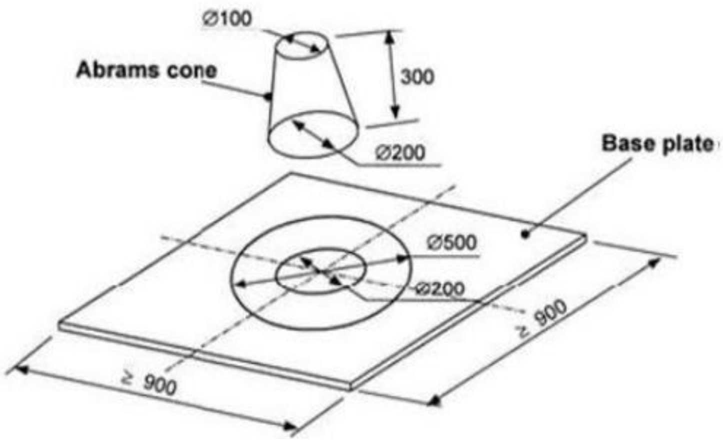

Fig-1: Representation of Slump Flow Apparatus

Table-3: Slump Flow Values

SLUMP FLOW					
	MIX 1	**MIX 2**	**MIX 3**	**MIX 4**	**MIX 5**
Length (mm)	495	500	505	515	520

4.1.2 V-Funnel Flow Test:

This test is used to determine the filling ability and segregation resistance of SCC mix, in this test the time of flow is the parameter to characterize the mix.

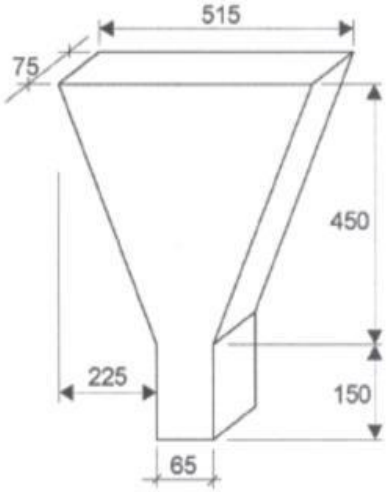

Fig-2: Representation of V-Funnel Apparatus

Table-4: V - Funnel Values

V-FUNNEL					
	MIX-1	**MIX-2**	**MIX-3**	**MIX-4**	**MIX-5**
TIME (sec)	30.2	26.4	22.5	21.9	18.3

4.2 Strength Tests

In general, the test on hardened concrete is done after the minimum 1 day of curing to 28 days of curing, the strength of concrete increases day after the other and reaches a level and stops in increase in strength and remains constant for a long stretch of years and then starts decreasing.
Mainly there are 3 important tests on hardened concrete:

1. Compression Test
2. Split Tensile Test
3. Flexural Test

4.2.1 Compression Test

Compressive strength is the most important property of cement among all the physical properties. Due to excess shrinkage and cracking of cement paste, compression test is not conducted on plain cement paste. Therefore, the test is conducted on concrete blocks which is defined as the characteristic compressive strength of 150 mm x 150mm x 150 mm size cubes tested at 1, 3, 7, 14, and 28 days as per Indian Standards.

Table-5: Compression Test Values

COMPRESSION TEST(N/mm²)								
Curing days	7 Days				28 Days			
	Cube-1	Cube-2	Cube-3	AVG	Cube-1	Cube-2	Cube-3	AVG
MIX 1	37.5	38.4	37.8	37.9	62.2	62.8	63.1	62.7
MIX 2	39.5	39.2	38.8	39.2	63.4	64.8	63.6	63.9
MIX 3	39.2	39.8	40.2	39.7	64.1	65.6	65.8	65.2
MIX 4	42.1	41.8	42.6	42.2	65.2	66.7	67.2	66.4
MIX 5	42.8	42.6	41.8	42.4	65.6	67.8	66.8	66.7

4.2.2 Split Tensile Test

As per Indian Standards, the Split Tensile test is conducted on cylindrical specimens of diameter 150 mm and length 300 mm. The Split tensile strength is used for the design of light weight structural concrete members. In this test, a vertical force is applied along the length of the cylinder at a rate which is within the limits. This loading causes tensile stresses on the plane containing the applied load as well as compressive stresses in the immediate vicinity of the applied load. Although we are applying a compressive load but due to Poisson's effect, tension gets produced and the specimen will fail in tension.

Table -6: Split Tensile Test Values

SPLIT TENSILE TEST (N/mm²)								
Curing Days	7 Days				28 Days			
	Cylinder-1	Cylinder-2	Cylinder-3	AVG	Cylinder-1	Cylinder-2	Cylinder-3	AVG
MIX-1	3.40	3.30	3.60	3.43	4.50	4.80	4.70	4.67
MIX-2	3.50	3.90	3.80	3.73	5.30	5.50	5.20	5.33
MIX-3	4.40	4.10	4.30	4.27	5.50	5.80	5.70	5.67
MIX-4	4.30	3.90	4.20	4.13	5.60	5.80	5.80	5.73
MIX-5	4.50	4.70	4.30	4.50	5.80	6.00	6.20	6.00

4.2.3 Flexure Test

Flexural strength is one of the tensile strength measurements; it is a measure of an unreinforced concrete beam's ability to withstand bending and it is determined by filling 100 mm x 100mm concrete beams with a span length of 500 mm.

This research is carried out using the third point loading test experiment, which distributes a single centered force across a steel beam to two points rather than one, spreading forces at the one third and two third points evenly from the top line.

Table-7: Flexure Test Values

FLEXURAL TEST (N/mm^2)								
Curing Days	**7 Days**				**28 Days**			
	Prism-1	**Prism-2**	**Prism-3**	**AVG**	**Prism-1**	**Prism-2**	**Prism-3**	**AVG**
MIX-1	6.50	6.90	6.60	6.67	8.40	8.60	8.20	8.40
MIX-2	6.90	7.30	7.10	7.10	8.50	8.80	8.60	8.63
MIX-3	7.30	7.10	7.40	7.27	8.50	9.20	9.40	9.03
MIX-4	7.20	7.30	7.50	7.33	8.80	9.40	9.20	9.13
MIX-5	7.80	7.50	7.40	7.57	9.40	9.40	9.60	9.47

5. RESULTS

5.1 Slump Flow Test Result

The below figure shows the slump flow of M60 grade concrete of which five trials were performed with change in Graphene Oxide percentages like 0.01, 0.03 and 0.05%.

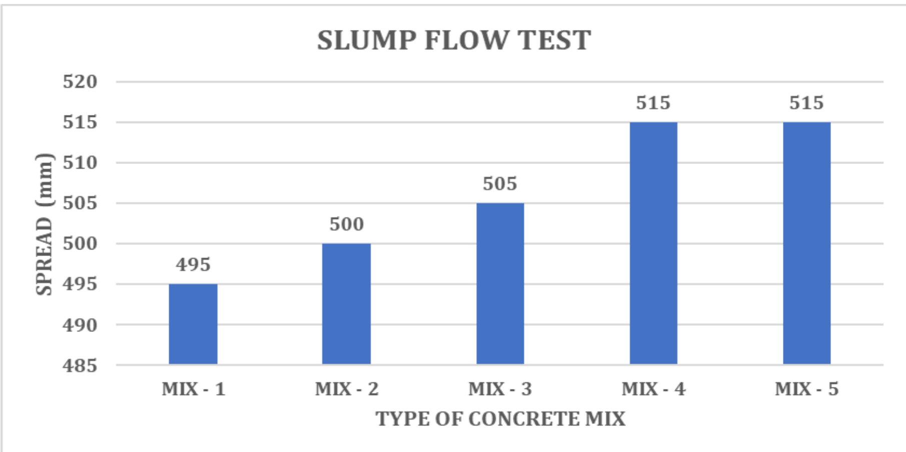

Chart- 1: Slump Flow Graph for different Mix

5.2 V-Funnel Test Result

The below figure shows the V-Funnel test value of M60 grade concrete of which five trials were performed with change in Graphene Oxide percentages like 0.01, 0.03 and 0.05%.

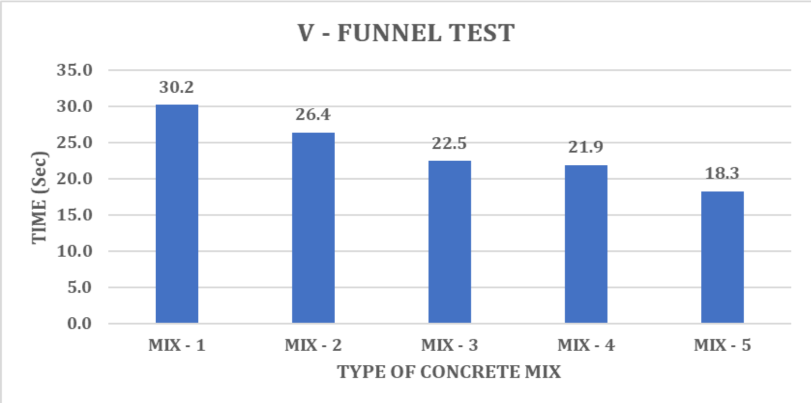

Chart-2: V-Funnel Graph for different Mix

5.3 Compression Test Result

The below figure shows the compressive strength of M60 grade concrete of which five trials were performed with change in Graphene Oxide percentages like 0.01, 0.03 and 0.05% and the test were conducted for both 7 and 28 days.

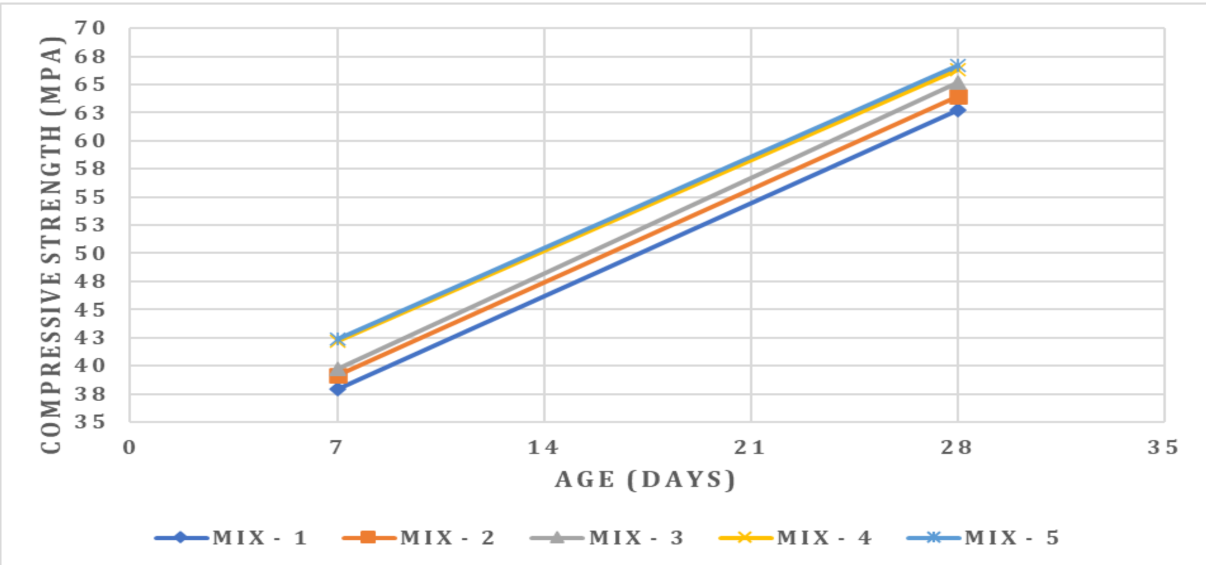

Chart-3: Compressive Strength Graph for Different Mixes

The compressive strength of high strength self-compacting concrete is conducted on 150 mm x 150 mm x 150 mm size cubes. The maximum compressive strength of 66.7 MPa is obtained at 28 days when there is a addition of 0.05% of Graphene Oxide to the weight of cement.

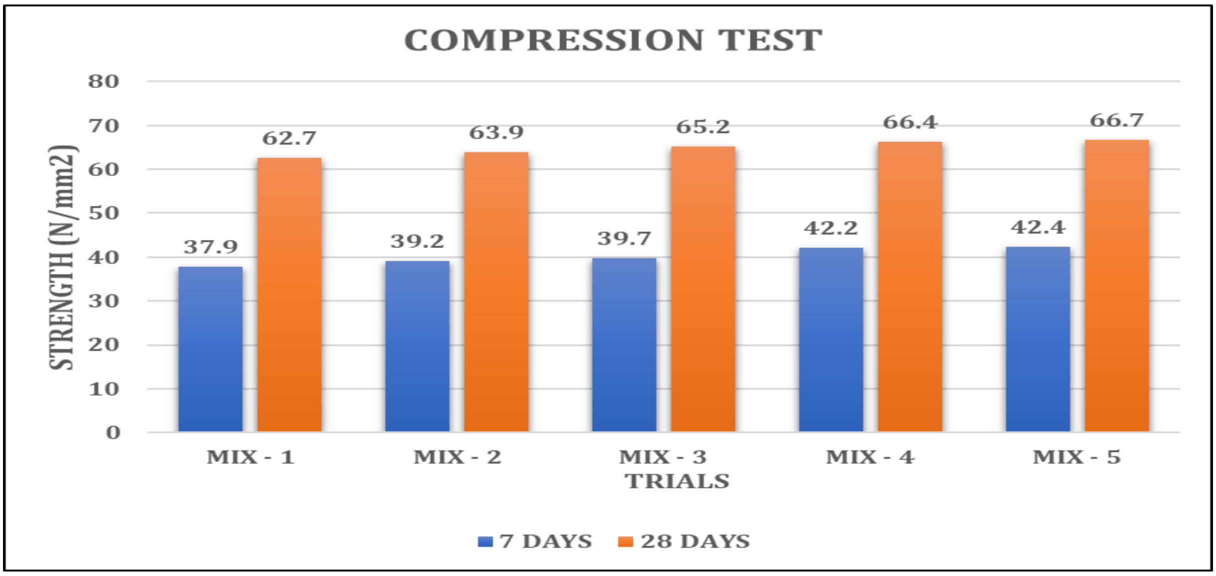

Chart-4: Compression Test Graph for Different Mixes

5.4 Split Tensile Test Result

The below figure shows the Split Tensile strength of M60 grade concrete of which five trials were performed with change in Graphene Oxide percentages like 0.01, 0.03 and 0.05% and the test were conducted for both 7 and 28 days.

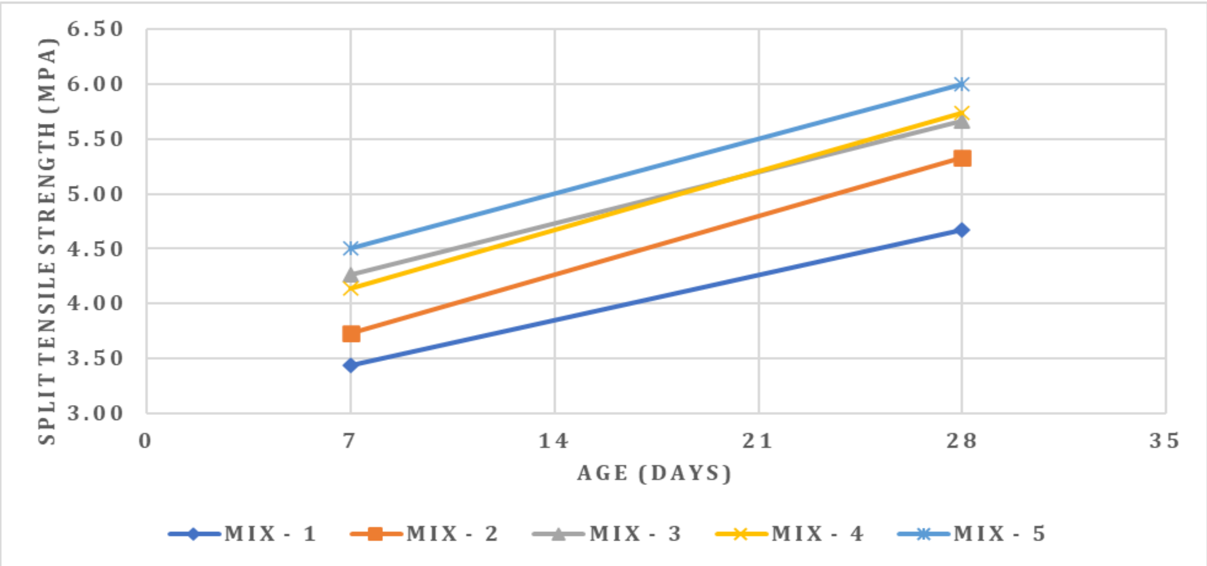

Chart-5: Split Tensile Strength Graph for Different Mixes

The split tensile strength of high strength concrete is conducted on 100 mm dia x 200 mm size cylinders. The maximum split tensile strength of 6.0 MPa is obtained at 28 days when there is a addition of 0.05% of Graphene Oxide to the weight of cement.

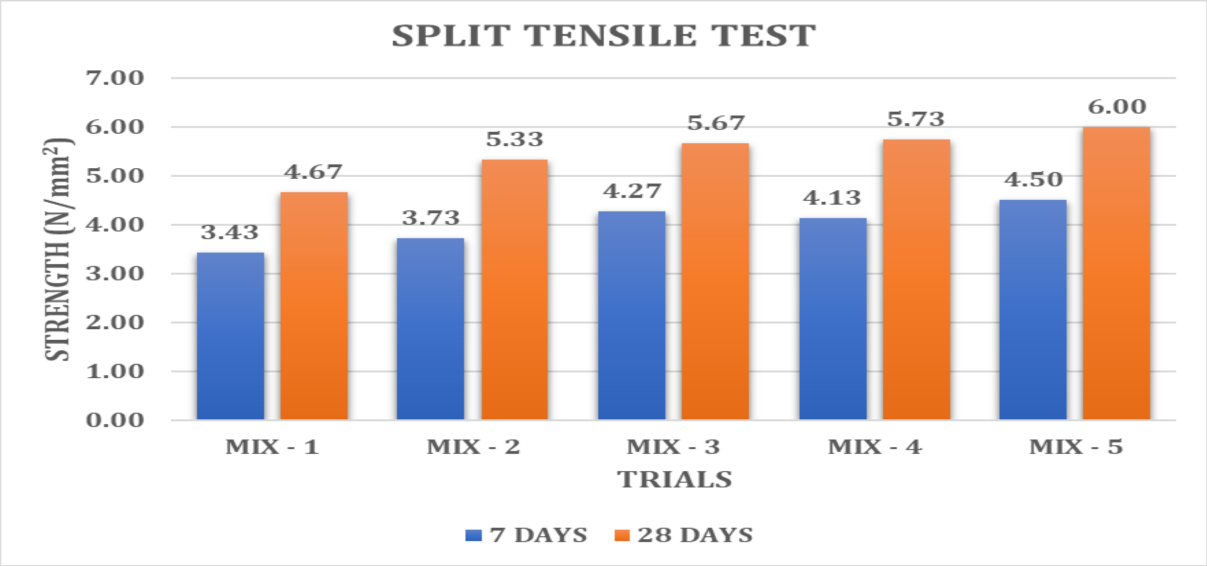

Chart-6: Split Tensile Strength Bar Graph

5.5 Flexural Test Result:

The below figure shows the flexural strength of M60 grade concrete of which five trials were performed with change in Graphene Oxide percentages like 0.01, 0.03 and 0.05% and the test were conducted for both 7 and 28 days.

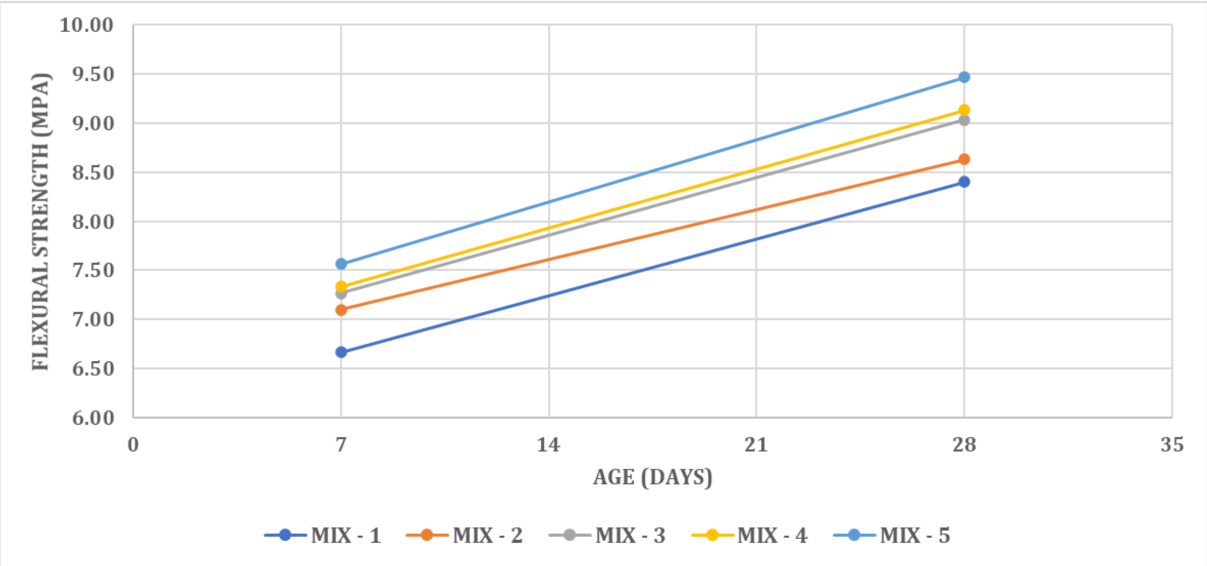

Chart-7: Flexure Strength Graph for Different Mixes

The flexural strength of high strength concrete is conducted on500 mm X 100 mm X 100 mm size beam, the maximum flexural strength of 9.7 MPa is obtained at 28 days when there is a addition of 0.05% of Graphene Oxide to the weight of cement.

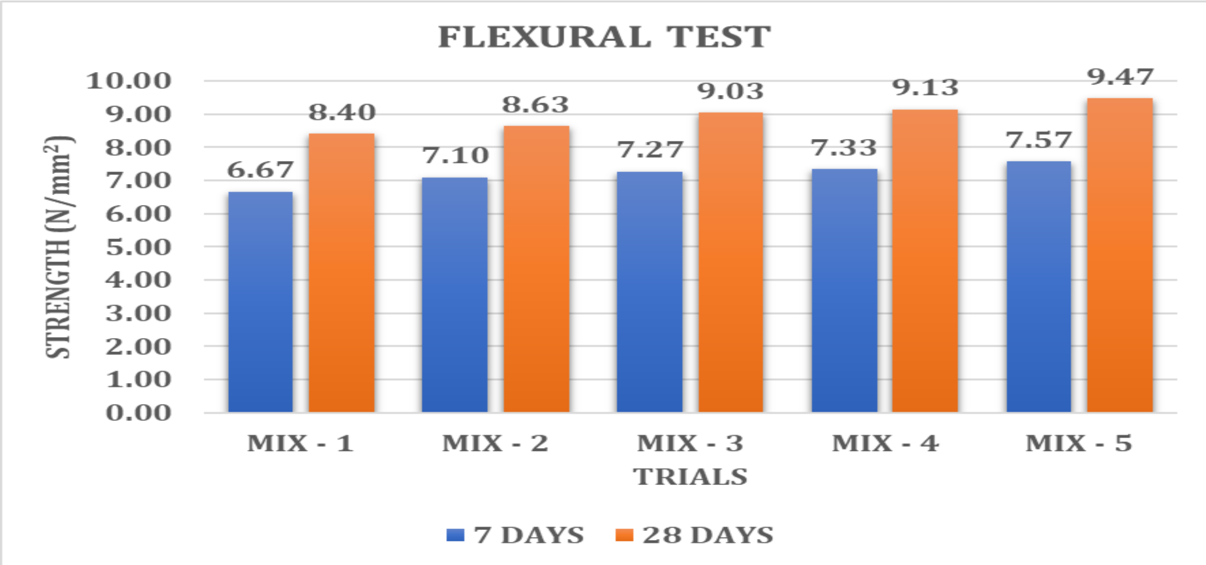

Chart-8: Flexure Strength Bar Graph

6. CONCLUSIONS

The maximum compressive strength about 66.7 MPa was obtained for 0.05% GO to the cement content, and similarly the maximum split tensile strength was 6.00 MPa and the maximum flexural strength was 9.47 MPa. Therefore, the compressive strength, split tensile and flexural strength values were improved when Graphene Oxide of 0.05% to the weight of cement is added to the self-compacting M60 grade concrete.

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