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EVALUATION OF STRENGTH PROPERTY OF CONCRETE BY USING GRAPHENE OXIDE AS A NANO ADDITIVE

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Abstract- In this experimental study, the effects of graphene oxide (GO) on portland cement paste are investigated. This project presents the results of an experimental investigation of graphene oxide on physical properties of concrete. This project aims to find out the optimum quantity of graphene oxide required to achieve maximum compressive, tensile and flexural strength of concrete. Graphene oxide was added to the concrete in five mix proportions. Graphene oxide content were varied by 0.03%, 0.05%, 0.08%, 0.10% and 0.13% of cement content. All the specimens were cured for the period of 7, 14 & 28 days before crushing. Tests were performed at the age of 7, 14 & 28 days. Test results indicated that the inclusion of graphene oxide in concrete enhanced the compressive, split tensile and flexural strength.

Keywords- Grapheme oxide, nano additive, compressive strength, split tensile strength, flexural strength.

I. INTRODUCTION

Concrete is used around us every day for buildings, roads, bridges and dams. It is actually a phenomenon of nature. It is formed by portland cement, water, sand and gravel is found to be the strongest material used for construction. Concrete has an advantage to be mounded into any shape. It can be casted at the work site reducing the cost of construction. It is a fire safe material and withstand high temperatures. It is the binding material used to bind together the fine aggregates and coarse aggregates together. These qualities and its ability to be moulded into different shapes made concrete very popular construction material and is used to build complex structures like dams, highways, bridges, houses etc[1]. Recent studies have demonstrated that there is a general trend of improvement in the properties of cementitious materials using mineral admixtures such as nanosilica. A small amount of nanosilica, if properly dispersed in to a mortar mix, can increase the strength of the mortar by more than 15%[2].

Concrete is composed of an amorphous paste phase, aggregate phase, interfacial transition zone and bound water. Calcium-silicate-hydrate (C-S-H gel) is an amorphous phase and is responsible for holding the aggregates together. The C-S-H gel is a nano material. The molecular structure, the bond length, strength and density of the chemical bonds forming during hydration can be studied by using nano-technology[3].

The graphene nanoparticles are expected to improve the cement matrix in a nanoscale. The functionalization of graphene using the remained oxygen atoms of functional groups or grafting the desirable molecules to react with the molecules expected to make the bonds with cement particles is a new field of interest in the graphene cement nanocomposites that may change the future of their civil engineering applications[4]. Graphene Oxide nanosheets can significantly enhance the strength and toughness of cement by regulating the microstructure of the cement hydration crystals, and therefore have great potential for practical application in the production of cement-based materials[5].

Benefits of Graphene Oxide[6]:
•Significant enhancement of the compressive and tensile strengths of cement and concrete
•Improved durability due to a finer pore structure of the composites
•Corrosion resistance

II. MATERIALS USED AND THEIR PROPERTIES

The materials include Cement, Graphene oxide, sand and Water. Details of each constituent are as follows.

A. **Nanoadmixer (Graphene Oxide):** Graphene oxide is used as nanoadmixer. It is used in different proportion (0.00% - 0.13%) for M-30 grade concrete with longer workability retention, mainly for ready mix concrete to enhance the compressive strength and flexural strength of the concrete.

B. **Cement:** Ordinary Portland cement of grade 53 make from a single lot is used for the study. The physical properties of cement as obtained from various tests are listed in Table 1. All the tests are carried out in accordance with procedure laid down in IS 1489 (Part 1):1991, valid for ordinary portland cements.

Table 1 Physical properties of cement

Sr. No.	Characteristics	Test Value	Value specified by IS :1489-1991 (Part 1)
1.	Standard Consistency in (%)	31	-
2.	Soundness (mm)	0.86	Max 10 mm
3.	Fineness of cement as retained on 90 micron sieve (%)	8%	-
4.	Setting time (min.) 1.Initial 2.Final	 90 180	 Min 30(min.) Max 600(min.)
5.	Specific gravity	3.12	

C. **Coarse aggregate:** crushed stone aggregates(locally available) of 20 mm and 10 mm are used through out the experimental study.the physical properties of coarse aggregate is given Table 2.

Table 2 Properties of Coarse aggregate

Sr. No.	Characteristics	Value	
		CA – I	CA - II
1.	Type	Crushed	Crushed
2.	Maximum nominal size (mm)	20 mm	10 mm
3.	Specific gravity	2.93	2.847
4.	Total water absorption	1 %	1.12 %
5.	Fineness modulus	7.67	5.97

D. **Sand (Fine Aggregates):** Locally available sand is used as fine aggregates in the preparation of the concrete mix. Grade 1 (particles size ranges from 600µm- 1.18 mm) and grade 2 (particle size ranges from 300µm-600µ) which conforms to IS 383:1970. The physical properties and sieve analysis results of sand are shown in Table 3.

Table 3 Physical Properties of Fine Aggregates

Sr. No.	Characteristics	Value
1.	Specific gravity (oven dry basis)	2.644
2.	Fineness modulus	3.35
3.	Water absorption	0.54 %
4.	Grading Zone (Based on percentage passing 60 µm sieve)	Zone III

E. **Water:** The water, which is used for making concrete and for curing, is clean and free from harmful impurities such as oil, alkali, acid, etc, in general, the water, which is fit for drinking is used for making concrete.

F. **Super plasticizer:** Master Glenium sky 8276 which is poly-carboxylic ether based hyper super plasticizer procured from BASF India Ltd construction chemicals- Ahmedabad.

Table 4 Properties of Super plasticizer

Sr. No.	Properties	Glenium 8276
1	Type of SP	Polycarboxylic ether
2	Appearance	Light brown
3	PH value	≥6
4	Specific gravity	1.08
5	Solid content	less than 30% by weight
6	Chloride content	<0.2%

III. EXPERIMENTAL PROGRAMME

A. Mix Design For M-30 grade Concretes

Table 5 Design stipulation

Grade of Concrete	M-30
Characteristic Compressive Strength (Mpa)	30
Maximum size of coarse aggregate (in mm)	20
Degree of workability (slump in mm)	75-100
Degree of Quality Control	Good
Type of Exposure (IS-456, Table - 5)	Moderate
Maximum water cement ratio (IS-456 -2000, Table -5)	0.5
Minimum cement content in kg (IS-456-2000, Table - 5)	300
Mode of placement	---
Type of Admixture	---

B. Mix Proportion Of trial 1 for 1m3 Concrete

Table 6 Mix proportion

Vol of Concrete (cu.m.)	1
Cement Content (kg)	420.02
Water Content (kg)	189.01
Fine aggregate (kg)	688.50
Kapachi (kg) (20 mm)	752.02
Grit (kg)	423.01
Admixture (kg)	0.00
Weight (kg)	2472.57
w/c ratio	0.45

C. Specimen preparation and curing

Casting and testing of specimen was carried out as per IS codes IS:516-1959 for compression strength, split tensile and flexural strength. Materials are weigh batched, mixed in a mixer, cast into steel moulds and specimens were stored in room temperature for 24 hours, then removed from the moulds, and cured in normal water until tested.

D. Testing

Cubes of size 150 mm × 150 mm × 150 mm were tested to compute compressive strength, cylinders of size 150 mm dia × 300 mm high were tested to compute split tensile strength and beam of size 150mm × 150 mm × 700mm were tested to compute flexural strength of concrete. Specimens were tested under the Compression testing machine of 3000 KN capacity. Average of 3cubes compressive strength, 3 cylinders split tensile strength and 3 beams flexural strength are tabulated.

IV. RESULTS AND DISCUSSION

A. Production process

By physical observation during concrete mixing, a long time is required for GRPC mixes to ensure that self flow able self-compacting consistency. The total mixing time is 15 min; the long time mixing is necessary for dispersing silica fume and quartz powder in well manner.

B. Mechanical properties

The test results of compressive strength, and split tensile strength, flexural strength and theoretical modulus of elasticity for corresponding mixes are tabulated.

1. Compressive strength

Standard metallic cube moulds (150*150*150 mm) were casted for compressive strength. A table vibrator was used for compaction of the hand filled concrete cubes. The specimens were de-moulded after 24 hours and subsequently immersed in water for different age of testing. For each age three specimens were tested for the determination of average compressive strength. The test was performed on compression testing machine having capacity of 200 MT.

Table 7 Result of Compressive strength of concrete

Graphene oxide in different proportion	Compressive strength (N/mm^2)		
	7 Days	14 Days	28 Days
Normal concrete	18.51	26.05	43.08
0.03 %	19.43	28.09	45.16
0.05 %	19.63	29.62	46.73
0.08 %	20.19	31.88	46.90
0.10 %	20.53	32.15	47.20
0.13 %	20.82	32.23	48.05

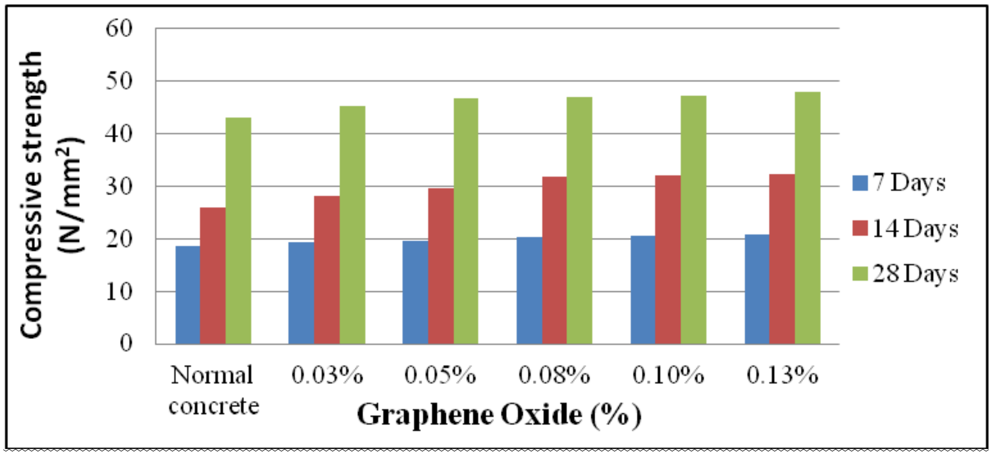

Figure 1 Compressive strength (N/mm^2) v/s Different proportion of Graphene oxide at 7 days, 14 days and 28 days

2. Split tensile strength:

Cylinders of 100 mm dia and 200 mm height were casted for Tensile Test. A table vibrator was used for compaction of the hand filled concrete cylinders. The specimens were de-moulded after 24 hours and subsequently immersed in water for different age of testing. For each age three specimens were tested for the determination of average strength.

Table 8 Result of Split tensile strength of concrete

Graphene oxide in different proportion	Split tensile strength (N/mm^2)		
	7 Days	14 Days	28 Days
Normal concrete	2.32	2.91	4.09
0.03 %	2.58	3.14	4.22
0.05 %	2.65	3.30	4.36
0.08 %	2.72	3.54	4.65
0.10 %	2.79	3.60	4.99
0.13 %	2.83	3.69	5.63

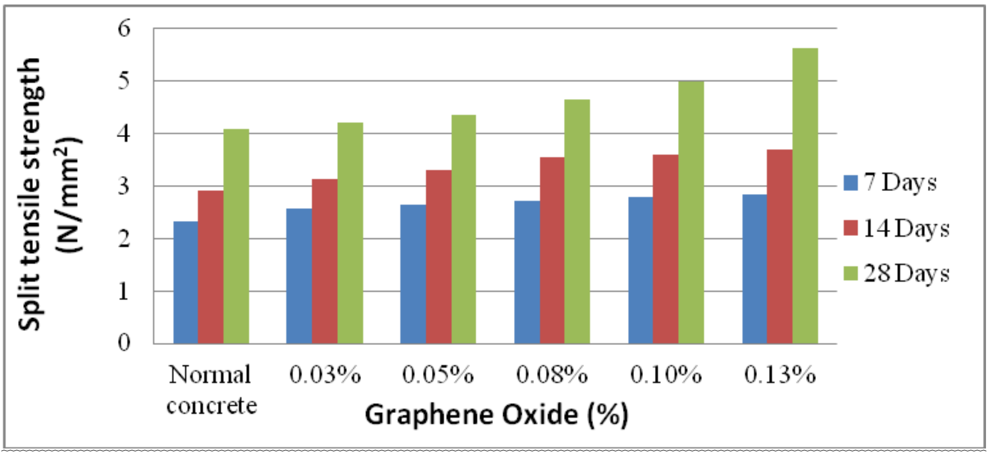

Figure 2 Split tensile strength (N/mm^2) v/s Different proportion of Graphene oxide at 7 days, 14 days and 28 days

3. Flexural strength test

Standard metallic beam moulds (100 mm * 100 mm * 500 mm) were casted for the preparation of concrete specimens for flexural strength. A table vibrator was used for compaction of the hand filled concrete beams. The specimens were de-moulded after 24 hours and subsequently immersed in water for different age of testing. For each age three specimens were used for the determination of average flexural strength. Test was performed on universal testing machine having capacity of 50 British tonne (BT).

Table 9 Result of Flexural strength of concrete

Graphene oxide in different proportion	Flexural strength (N/mm^2)		
	7 Days	14 Days	28 Days
Normal concrete	2.39	2.78	3.85
0.03 %	2.19	3.16	4.13
0.05 %	2.28	3.31	4.29
0.08 %	2.53	3.55	4.52
0.10 %	2.75	3.69	4.92
0.13 %	2.82	3.75	5.30

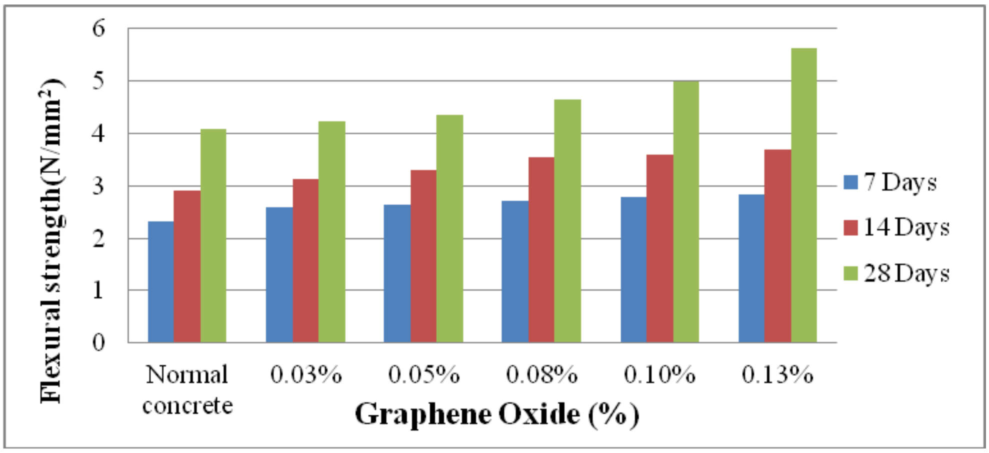

Figure 3 Flexural strength (N/mm^2) v/s Different proportion of Graphene oxide

V. CONCLUSIONS

Addition of graphene oxide leads to an increase in compressive strength, tensile strength and flexural strength. The different proportion of Graphene oxide (0.03%, 0.05%, 0.08%, 0.10%, 0.13%) in Portland cement the compressive strength, tensile strength and flexural strength. The test results exhibit the increase in the strength with the addition of grapheme oxide. When compared with the nominal mix the other mixes shown increase in strength at the end of 7days, 14 days and 28 days. The maximum increase in strength was obsereved in the end of the 28 days. The addition of GO improves the degree of hydration of the cement paste and increases the density of the cement matrix, creating a more durable product.

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