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STUDY OF MECHANICAL PERFORMANCE OF CONCRETE WITH THE ADDITION OF GRAPHENE OXIDE AS ADMIXTURE

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Abstract - *As the consumption of concrete increases, the production of cement is growing day by day. Portland cement process is a highly energetic process, and emits carbondioxide during calcination which has a crucial effect on global warming. Concrete, being the most widely used cement composite since it bears many advantages such as low cost, easy availability of constituents along with high strength and durability. However, disadvantages such as low tensile and flexural strength coupled with brittleness have promoted the addition of nanomaterials such as carbon nanotubes, graphene oxide, graphene nan flakes etc. The graphene oxide is chemically known as 'r-GO' ,atomically composite carbon, oxygen and hydrogen, a three-dimensional structure composed of millions of layers of graphite; existing in all body cast plain concrete or reinforced and which is possible to peel in the water, creating highly resistant layers in the material in which you are dispersed. This paper presents the strength properties of GO in cement- based composites such as compressive strength, flexural strength and tensile strength .*

Key Words: *Graphene Oxide*

1.INTRODUCTION

1.1 Introduction to Graphene Oxide

Cementitious materials are the most common construction materials used worldwide. They are generally brittle and have very low tensile strength and strain capacity. The concept behind such a transition to fiber-reinforced cement is that the resulting tensile strength is developed from many individual fibers rather than a few pieces of steel. Thus, use of discrete fibers results in greater uniform distribution of stress within cementitious materials Recently, carbon nanostructures such as carbon nanotubes (CNTs, both single and multiwalled), carbon nanofibers (CNFs), and Graphene have attracted attention from many concrete researchers due to their exceptional mechanical, chemical, thermal, and electrical properties, and good performance as polymeric reinforcement materials .Graphene is a single layer sp^2-bonded carbon sheet forming a honeycomb crystal lattice. Exfoliated graphene nanoplatelets have the same chemical structure as Carbon Nanotubes (CNT), and their edges are easily chemically modified for enhanced dispersion in polymeric composites [5]. Such nanoplatelets are typically less than 5 nm thick and can be synthesized with lateral dimensions ranging from <1 to 100 microns. Use of graphene oxide powder could open up many new applications such as high tensile strength and high compressive strength.

Fig - 1: Graphene Oxide

2. OBJECTIVES

The main objectives of this study are as follows.

- To study the behavior of concrete with Graphene oxide.
- To determine the compressive strength and flexural strength of Graphene oxide concrete.
- To find out the optimum quantity of Graphene Oxide required to achieve maximum compressive and flexural strength of concrete.

3. EXPERIMENTAL SETUP

The materials used for making the concrete mix are Portland Pozzolona Cement (PPC), fine aggregate, coarse aggregate and water. The properties of each of these materials contribute to the quality of concrete produced. In the present study, the material test for various materials were conducted as specified in the relevant IS codes for each material.

3.1 Test for cement

3.1.1 Fineness test

Fineness is the property of cement that indicates the particle size of cement and specific surface area. The fineness of cement has an important bearing on the rate of hydration and results in the rate of gain of strength. Finer particle of cement offers a greater surface area for hydration and leads to faster development of strength. 100grams of cement was taken and sieved through IS Sieve No.9 (90 microns). The air set lumps in the sample were broken with fingers. The sample was continuously sieved for 15 minutes by hand. The residue left on the sieve was weighed. The weight obtained should not be more than 10 pecent of the original weight as per IS:12269-2013. The fineness of cement obtained was 1%.

3.1.2 Normal consistency

The Normal consistency test is done to find out the amount of water to be added to the cement to get a paste of normal consistency. 300 grams of cement was taken and made into a paste with a weighed quantity of water for the first trial. The paste was prepared in a standard manner and filled into the Vicat's mould plunger which is 10mm in diameter and 50mm long. The plunger was attached and brought down to touch the surface of the paste in the test block and quickly released allowing it to sink into the paste by its own weight. The depth of penetration of the plunger was till such time the plunger penetrates for a depth of 33-35mm from the top. The percentage of water, which allows the plunger to penetrate only to a depth of 33-35 mm from the top, is known as the percentage of water required to produce a cement paste of standard consistency. The obtained value was 34% which is within the range.

3.1.3 Initial and final setting time

The needle of the Vicat apparatus was lowered gently and brought in contact with the surface of the test block and quickly released. It was allowed to penetrate into the test block.

The needle completely pierced through the test block in the beginning. The period of elapsing between the time when water is added to the cement and the time at which the needle penetrates the test block to a depth equal to 33-35mm from the top was taken as the initial setting time.

Final setting time was found out using an annular attachment. As per IS : 1489(PART 1) :1991, the initial setting time of PPC should be greater than 30 minutes an d the final setting time should be less than 600 minutes. The obtained values for initial and final setting time are 75 minutes and 255 minutes .

3.2 Test on fine aggregate

Fine aggregates composed of natural sand or crushed stone with most particles passing through a 4.75mm sieve. Fine aggregates are particles which are used to improve the uniformity and workability in concrete mix. The fine aggregate used in this project was M sand. Clean and dry M sand passing through IS 4.75 mm sieve was used for casting all specimens. The specific gravity test and sieve analysis were conducted on M sand.

3.2.1 Sieve Analysis

The sample was brought to an air-dry condition. The required quantity of the sample was taken (2kg). Sieving was done for 5 minutes. The materials retained on each sieve after shaking, represents the fraction of the aggregate coarser than the sieve considered and finer than the sieve above. The weight of aggregates retained on each sieve was measured and converted to a total sample. Fineness modulus was determined as the ratio of summation of cumulative percentage weight retained to 100 and the value obtained was 3.9. Hence it belongs to Zone II. The sieve analysis was performed on M sand and particle size distribution gives the grading curves for M sand.

3.2.2 Specific Gravity

Specific Gravity of a substance is the ratio of the unit weight of substance to unit weight of water. Applied to aggregate , it refers to the density to the individual particles and not the aggregate mass as a whole. The given container is cleaned and weighed (W1).1/3 rd of it is filled by the given aggregate and then compacted. The container with compacted material is weighed (W2).Water is poured in to the container until the voids are filled and weight is again noted.(W3).The container is emptied and again filled with loose material. The container with this content is weighed. (W4).The voids are then filled with water and weighed (W5). The container is emptied and again filled with water and the weight is noted (W6).Specific gravity is calculated as shown below. The range of specific gravity varies from 2.6 to 2.8.

3.3 Test on coarse aggregate

Crushed natural stone of size less than 20mm were used as coarse aggregate for the project work.

3.3.1 Sieve Analysis

The sample was brought to an air-dry condition. The required quantity of the sample was taken 5 kg. Sieving was done for 5 minutes. The materials retained on each sieve after shaking, represents the fraction of the aggregate coarser than the sieve considered and finer than the sieve above. The weight of aggregates retained on each sieve was measured and converted to a total sample. Fineness modulus was determined as the ratio of summation of cumulative percentage weight retained to 100 and the value obtained was 5.9. The sieve analysis was performed on coarse aggregate and particle distribution of the coarse aggregate gives the grading curve for coarse aggregate.

3.3.2 Specific Gravity

Specific Gravity of a substance is the ratio of the unit weight of substance to unit weight of water. Applied to aggregate , it refers to the density to the individual particles and not the aggregate mass as a whole. The given container is cleaned and weighed (W1).1/3 rd of it is filled by the given aggregate and then compacted. The container with compacted material is weighed (W2).Water is poured in to the container until the voids are filled and weight is again noted.(W3).The container is emptied and again filled with loose material. The container with this content is weighed. (W4). The voids are then filled with water and weighed (W5).The container is emptied and again filled with water and the weight is noted(W6). Specific gravity is calculated as shown below. The range of specific gravity varies from 2.6 to 2.8 .

3.3 Mix proportion

The mix is designed by using the values from the material test. The mix design is carried out as per IS: 10262- 2019. The cement used is PPC . M sand is used as fine aggregate and has a specific gravity of 2.5 and it belongs to zone II. Water cement ratio of 0.55

4.RESULT AND DISCUSSION

4.1Compressive Strength Test

The compressive strength results of concrete specimens with various percentage of graphene oxide concrete by testing six cube specimens on 56th day of curing are given below in Table 4.1 .

1CGO0, 2CGO0, 3CGO0, 4CGO0, 5CGO0 and 6CGO0

represents addition of Graphene Oxide at 0 %.

Similarly 1GO1, 2GO1 and 3GO1 represents addition of

Graphen Oxide at 1%

Table 4.1 Compressive strength results

Control Specimen	Compressive Strength (N/sq.mm)
1CGO0	25.35
2CGO0	25.68
3CGO0	24.79
4CGO0	26.32
5CGO0	26.3
6CGO0	25.2
With 1 % Graphene Oxide	
1GO1	26.12
2GO1	25.96
3GO1	26.8
4GO1	25.44
5GO1	25.2
6GO1	25.9
With 1.5 % Graphene oxide	
1GO1.5	25.9
2GO1.5	26.38
3GO1.5	25.98
4GO1.5	26.53
5GO1.5	26.26
6GO1.5	26.39
With 2% Graphene Oxide	
1GO2	26.12
2GO2	25.96
3GO2	**26.8**
4GO2	25.44
5GO2	25.2
6GO2	25.9

The maximum compressive strength was obtained as 26.8 N/ Sq.mm It was obtained on the addition of 2% Graphene oxide

4.2 Split Tensile strength

In the split tensile strength test, the tensile strength of concrete is obtained by applying a compressive force along the length of the concrete cylinder. The specimen used for this method is of cylindrical in size. The Split tensile strength results are shown on Table 4.2

Table -4.2: Tensile Strength Results

Control Mix	Tensile Strength (N/sq.mm)
1CGO0	2.654
2CGO0	2.67
3CGO0	2.505
With 1% Graphene Oxide	
1GO1	3.12
2GO1	3.246
3GO1	3.459
With 1.5% Graphene Oxide	
1GO1.5	3.45
2GO1.5	3.549
3GO1.5	3.62
With 2% Graphene Oxide	
1GO2	3.66
2GO2	3.652
3GO2	**3.687**

The maximum tensile strength was obtained as **3.687 N/Sqmm** . It was obtained on the addition of 2% Graphene oxide

4.3 Flexural Strength

Flexural strength is a one measure of the tensile strength of concrete. It tests the ability of unreinforced concrete beam or slab to withstand failure in bending.

Table -4.3 Flexural Strength Results

Control Mix	Flexural Strength (N/sq.mm)
1CGO0	17.97
2CGO0	17.99
3CGO0	17.95
With 1% Graphene Oxide	
1GO1	18.635
2GO1	19.12
With 1.5 % Graphene Oxide	
1GO1.5	19.32
1GO1.5	19.310
With 2% Graphene Oxide	
1GO2	19.56
1GO2	**19.75**

The maximum flexural strength was obtained as **19.75 N/sq.mm.** It was obtained on the addition of 2% Graphene oxide

5. CONCLUSIONS

The following results were made on the incorporation of various percentage of Graphene oxide with cement

- Incorporation of Graphene oxide in concrete showed modifications in mechanical properties.
- Nano particles of graphene oxide improved the mechanical properties of the concrete such as compression, flexural and split tensile strength . Graphene oxide were mixed at 1%, 1.5% and 2 % with cement. It is carried out for M20 grade of concrete
- The maximum compressive strength was obtained as 26.8 N/Sq.mm at 2% addition of Graphene Oxide.
- The maximum flexural strength was obtained as 17.5 N/Sq.mm at 2% addition of Graphene Oxide.
- The maximum tensile strength was obtained as 3.687 N/Sq.mm at 2% addition of Graphene Oxide.
- The maximum value for compressive strength, flexural strength and split tensile strength was obtained when Graphene oxide percentage of 2% was mixed with concrete.

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