

INVESTIGATION ON STRENGTH PROPERTIES OF GRAPHENE OXIDE CONCRETE

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Abstract— This project presents the results of an experimental investigation of graphene oxide on physical properties of concrete. This article 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 three mix proportions. Graphene oxide content was varied by 0.05%, 0.1%, 0.2% 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— Concrete, grapheme oxide, compressive strength, split tensile strength, flexural strength.

I. INTRODUCTION

Concrete is a composite material of aggregates and binders where binding materials are primarily a combination of Portland cement, pozzolanic materials and water. Hydration of cement generates heat due to the exothermic nature of the hydration process. The phases mainly responsible for heat generation during the hydration process are tricalcium silicate (C3S), dicalcium silicate (C2S), tricalcium aluminate (C3A) and tetracalcium aluminoferrite (C4AF). The hydration process of Portland cement depends on several factors or parameters such as cement mineralogical composition, particle size distribution, water to cement ratio and curing temperature. Due to the exothermic nature of the reaction combined with poor heat dissipation in massive concrete elements, the hydration process results in a temperature gradient between the inner core and the outer surface of the element. The high temperature gradient is known to result in large tensile stresses that may exceed the tensile strength of concrete thus leading to thermal cracking. The temperature

gradient minimization in an element could be achieved through lowering the temperature rise due to hydration and/or improving heat dissipation by increasing thermal conductivity of concrete. Improving the paste thermal conductivity reduces the temperature gradient in the concrete element, thus reducing the probability of concrete thermal cracking.

Zhou fan [1] studied that the results of the GC, GOM, GM and GOC can improve the compressive strength of cementitious materials. The compressive strength of them is 19.9%, 13.2%, 11.5% and 10.2% higher than the normal mortar, respectively. The GC can effectively improve the water preserving ability of cementitious materials and thus it will weaken the frost resistance of harden Portland cement, whereas the GOM can slightly improve the frost resistance of cementitious materials. The corrosion resistance of cementitious materials within 5 months can be boosted by the GC and GOM, while this can be weakened by the GM. From the current experimental data, the GC and GOM are more likely to raise long-term acid corrosion resistance of concrete. Nitric acid oxidation of graphene nanoplatelets on improving the cementitious material strength is not as good as expected. However, the oxidation treatment is necessary because it can mitigate the detrimental effect of plain graphene particles on frost resistance of cementitious materials. The performance of the GOM group is best among all the experimental groups, by comprehensive consideration of all the experimental results. The Raman spectroscopy observation is powerful when locating graphene nanoplatelets in the cement surface. It can help the

researchers to locate the graphene in AFM observation to make the images obtained in AFM are more credible rather than only judging the existing of graphene by topography.

Ahmadreza Sedaghat, A. Zayed [2] studied the incorporation of graphene nanoparticles in cement paste showed interesting modifications in microstructural, morphological, electrical and thermal properties of the paste. Thermal diffusivity and electrical conductivity were found to increase with increasing the graphene content in the composite. The increase in thermal diffusivity of the hydrated graphene cement composite is a clear indication of the heat sink capacity of graphene. This effect is of significant importance especially during the exothermic reactions taking place during the initial stages of hydration of portland cement. The hydrated graphene-cement samples indicate the presence of graphitic plane in the composite structure. The rod or needle-shaped morphology of ettringite, which is typically observed in hydrated cement paste, was less prevalent in the graphene composites and appeared to be affected by graphene content. The metal oxides in cement act as a catalyst for the oxidation of graphene at higher temperatures (600°C to 750°C), regardless of the quantity of graphene present in cement-based composite. The impact of the incremental increase of graphene on the electrical conductivity of the composites indicates the potential of using graphene in application where electrostatic dissipation (ESD) of charge is desirable.

Fakhim Babak, Hassani Abolfazl [3] synthesized GO via exfoliation of graphite oxide prepared by a colloidal suspension route and was used to prepare GO-cement nanocomposites (GCNC) using an ultrasonic method. A polycarboxylate super plasticizer (0.5 wt% of cement) was used to improve the adhesion properties of the GO and uniformly disperse it in the cement matrix. Use of an optimal percentage (1.5wt %) of GO nanoplatelets caused a 48% increase in the tensile strength of the cement mortar specimens. Moreover, using FE-SEM observation of the fracture surface of the samples containing 1.5wt% GO revealed that the GO nanoplatelets were well dispersed and no GO agglomerates were

seen in the matrix. In addition, XRD data shows growth of the calcium silicate hydrates (C-S-H) gels in GO cement mortar compared with the normal cement mortar. It can be because of the nucleation of C-S-H by the GO flakes which was shown in FE-SEM images. The hydrated cement products deposited on the GO flakes due to their higher surface energy and the presence of hydrophilic groups on the GO surfaces acted as a nucleation site. The results indicated that the main reason for the observed high bond strength was the nucleation of C-S-H by the GO flakes and its formation along them. FE-SEM observation also revealed microcracks in the GO flakes, implying that the GO flakes stretched across microcracks in the mortar. The breakage observed indicated that very high stresses were applied to the GO flakes. Because the theoretical tensile strength of GO flake is very high, more GO flakes are needed to carry stresses. The tensile strength of specimens containing 2 wt% GO flakes was much less than that of the control samples. This behavior was justified by taking into account that GO was hydrophilic enough to absorb most of the water contained in the cement mortar, hampering the proper hydration of the cement mortar and making dispersion of the GO within the matrix difficult. This hypothesis was confirmed by the 24.7% increase obtained in the tensile strength of specimens containing 2wt% GO at a water/cement ratio of 0.5 compared with that of the sample containing 2.0wt% GO at a water/cement ratio of 0.4.

Virginie Wiktor [4] conducted laboratory tests to show that only 0.05% of GO is needed to improve flexural strength of an OPC matrix from between 41% to 59% and compressive strength from between 15% to 33%. Laboratory tests also show that the addition of 0.05% GO improves pore structure and decreases total porosity from 32.6% to 28.2%, providing higher compressive strength and a more durable product. 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.

II. METHODOLOGY

Selection of each material likes Cement, Aggregates, Chemical admixture and water of appropriate quality is very crucial to find strength studies on cement concrete.

Cement: Ordinary Portland cement, 53 Grade conforming to IS: 12269 – 1987. Specific gravity of cement is 3.15.

Fine Aggregate: Locally available river sand confined Grading zone II of IS: 383-1970. Specific gravity of fine aggregate is 2.6.

Coarse Aggregate: Locally available crushed blue granite stones conforming to graded aggregate of nominal size 12.5 mm as per IS: 383 – 1970. Its specific gravity is 2.75.

Chemical Admixture: Chemical prepared from graphite powder and other chemicals to enhance the strength parameters of the concrete.

Water - Potable water as per IS 456-2000.

The mix design was done for M25 grade concrete based on the IS: 10262-2009. Water cement ratio adopted as 0.50.

TABLE 1
 NOMINAL MIX PROPORTION

Mix	% of Graphene oxide	Water (litre)	Cement (kg/m ³)	Fine Aggregate (kg/m ³)	Coarse Aggregate (kg/m ³)	Graphene oxide (kg/m ³)
M0	-	192	384	715	1113	-
M1	0.05	192	384	715	1113	0.19
M2	0.1	192	384	715	1113	0.38
M3	0.2	192	384	715	1113	0.76

Concrete cubes of size 150mm x 150mm x 150mm and cylinders of size 150mm diameter and 300mm height were casted for the above proportions of concrete to test the compressive strength, the split tensile strength and flexural strength.

III. RESULTS AND DISCUSSIONS

TABLE 2
 COMPRESSIVE STRENGTH TEST RESULT

MIX	GO BY % OF CEMENT	AVERAGE COMPRESSIVE STRENGTH MPa		
		7 days	14 days	28 days
M1	0	15.75	21.00	24.60
M2	0.05	15.40	21.25	25.30
M3	0.1	18.00	23.87	27.05
M4	0.2	17.12	22.05	26.65

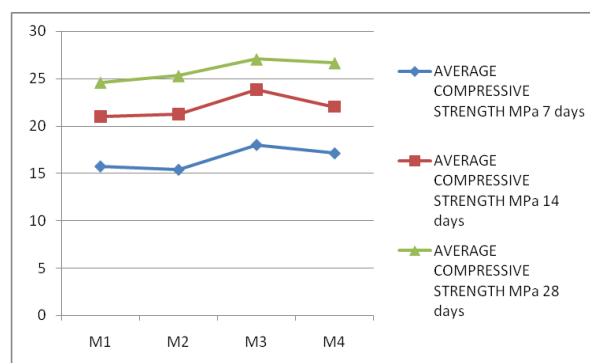


Fig 1. Compressive Strength results

TABLE 3
 SPLIT TENSILE STRENGTH TEST RESULT

MIX	GO BY % OF CEMENT	AVERAGE SPLIT TENSILE STRENGTH MPa		
		7 days	14 days	28 days
M1	0	2.40	2.82	3.15
M2	0.05	2.30	2.65	3.07
M3	0.1	2.41	2.85	3.18
M4	0.2	2.33	2.57	3.05

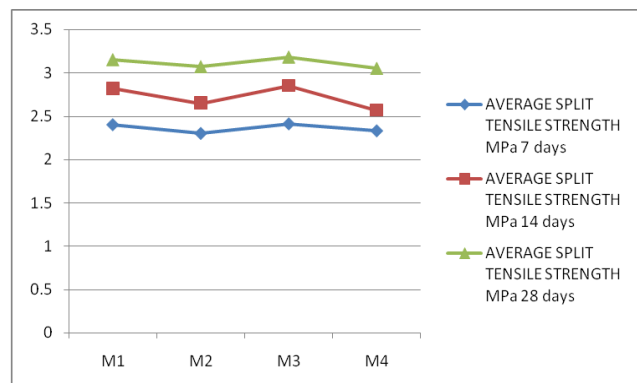


Fig 2. Split Tensile Strength Results

Table 4
 Flexural Strength Test Result

MIX	GO BY % OF CEMENT	AVERAGE FLEXURAL STRENGTH MPa		
		7 days	14 days	28 days
M1	0	3.80	4.27	4.71
M2	0.05	3.77	4.33	4.76
M3	0.1	3.96	4.45	4.82
M4	0.2	3.65	4.30	4.74

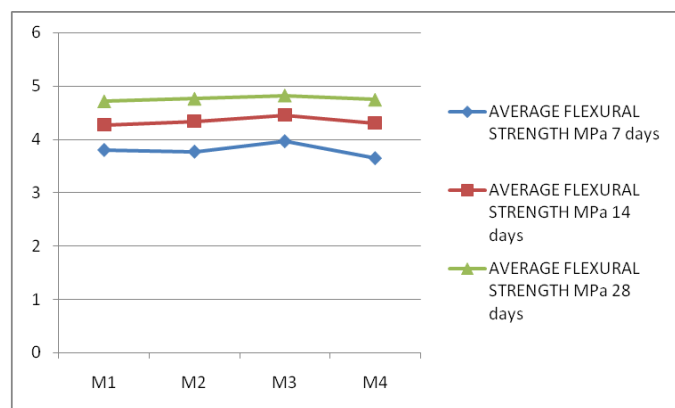


Fig 3. Flexural Strength Results

The test results exhibit the increase in the strength with the addition of graphene oxide. When compared with the nominal mix the other mixes shown increase in strength at the end of 28 days.

IV. CONCLUSION

1. Addition of graphene oxide leads to an increase in compressive strength, tensile strength and flexural strength.
2. 0.1% of GO is needed to improve flexural strength of an PPC matrix about 4% and compressive strength about 11%.
3. 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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