International Journal of Innovative Research in Engineering & Management (IJIREM)
ISSN: 2350-0557, Volume-3, Special Issue-1, April-2015
Fifth National Conference on Innovative Practice in Construction Waste Management (IPCWM'15) On 8th & 9th April, 2015
Organized by Department of CIVIL Engineering, Sri Ramakrishna Institute of Technology, Coimbatore, India

Experimental Studies on Properties of Graphene Cement Composites

K. Akil
Professor of Civil Engineering,
College of Engineering and Technology,
Coimbatore.

Menta Harikrishna, Yadav Somani
Final Year Civil Engineering,
Hindusthan College of Engineering and Technology,
Coimbatore.

ABSTRACT
In this study, properties of graphene cement composites were investigated. Studies were made on graphene cement composites having graphene of 0.2%, 0.4%, 0.6%, 0.8% and 1% by weight of cement in cement mortar mix 1:3. Properties of various constituents used in the study were determined. Compressive strength, flexural strength and split tensile strength for the graphene cement composites were evaluated and compared with that of the reference cement mortar. Results showed an improvement in the properties of graphene cement composites over the reference cement mortar.

Keywords
Graphene cement composites, compressive strength, flexural strength, split tensile strength

1. INTRODUCTION
A nanomaterial is a material with any external dimension in the nanoscale or having internal structure or surface in the nanoscale. Most of the nanomaterials could be organized into the following four types: carbon based materials, metal based materials, dendrimers, and composites [1].
Carbon based nanomaterials are composed mostly of carbon, most commonly taking the form of a hollow spheres, ellipsoids, or tubes Metal based nanomaterials include quantum dots, nanogold, nanosilver and metal oxides, such as titanium dioxide. Dendrimers are nanosized polymers built from branched units. The surface of a dendrimer has numerous chain ends, which can be tailored to perform specific chemical functions. Composites combine nanoparticles with other nanoparticles or with larger, bulk-type materials.
Carbon nanotubes increase the compressive strength of cement mortar specimens and change their electrical properties which can be used for health monitoring and damage detection [2].
The addition of small amounts of carbon nanotubes can improve the mechanical properties of mixture samples of Portland cement and water. Oxidized multi-walled nanotubes show the best improvements both in compressive strength and flexural strength compared to the normal concrete samples.
This papers deals with the studies made on the properties of graphene cement composites (GCC). Graphene is the strongest material discovered and is 100 times stronger than steel but six times lighter [3]. It is the thinnest material on earth which is transparent, flexible and impermeable.

2. MATERIALS AND METHODS
Graphene is a two-dimensional one atom thin sheet of carbon atoms in which the structure is quite similar to graphite. "Graphene" refers to a single layer of graphite, and in some cases means a few layers of graphite as well. The carbons are perfectly distributed in a hexagonal honeycomb formation. Figure 1 depicts the structural view of graphene.

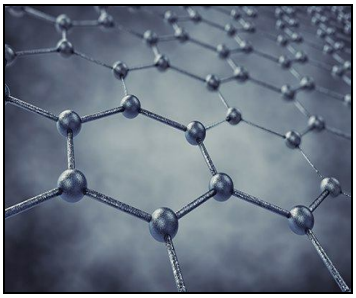

Figure 1. Structural view of graphene

Due to the nano particle size of graphene, dimethyl formamide (DMF) was used for uniform mixing of graphene with cement mortar. 10mL of DMF and 1 mL of water were added to every gram of graphene used [4]. It was then mixed with cement mortar.
OPC 53grade cement was used for the study. The normal consistency test, setting time test and the soundness test were performed on the cement used for the study. Fine aggregate was tested for moisture content, specific gravity and particle size distribution. Water used was tested for pH, chlorides, sulphates and total dissolved solids (TDS).
Cement mortar mix (CM 1:3) was prepared with 0%, 0.2%, 0.4%, 0.6%, 0.8% and 1% graphene (by weight of weight). Cube specimens of size 70.6mm x 70.6mm x 70.6mm for compressive strength, prism specimens of size 100mm x 100mm x 500mm for flexural strength and cylinder specimens of size 100mm x 200mm for split tensile strength were cast. The test specimens were de-moulded after 24 hours and subjected to water curing.

Compressive strength, flexural strength and split tensile strength was determined at the end of 7 days, 14 days and 28 days.
Figure 2 shows the compression test conducted on cube specimens, Figure 3 shows the flexure test conducted on prism specimens and Figure 4 shows the split tensile test conducted on cylinder specimens.

Figure 2. Compression test

Figure 3. Flexure test

Figure 4. Split tensile test

3. RESULTS AND DISCUSSION

The particle size of graphene used in the study was calculated from the XRD image shown in Figure 5. The size of graphene particles used was 49nm.

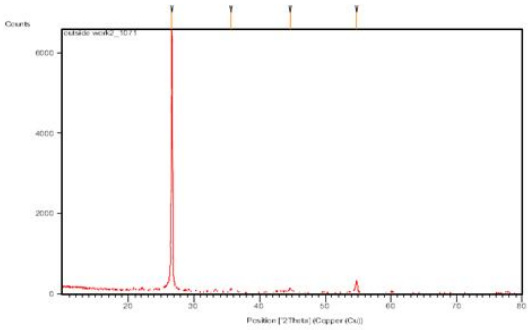

Figure 5. XRD image of graphene

The consistency, initial setting time, final setting time and the soundness of cement used in the study were 30%, 33 minutes, 327 minutes and 4mm respectively. The moisture content and the specific gravity of fine aggregate were 0%, 1.862 respectively. The fine aggregate used belonged to zone III type. pH, chlorides, sulphates and TDS of the water used were 7.2, 88.75mg/L, 90.5mg/L and 157.92mg/L respectively. All the parameters tested for various constituents were within the acceptable limits used for construction.
Table 1 presents the compressive strength of GCC for varying percentages of graphene at the end of 7, 14 and 28 days. The compressive strength was found to increase with the increase in the graphene content. This could be attributed to the enhancement in the binding characteristics of the composite.

Table 1. Compressive strength of GCC

No. of days	Average compressive strength of GCC N/mm^2					
	0.0%	0.2%	0.4%	0.6%	0.8%	1.0%
7	35.32	35.59	36.64	36.94	37.23	37.72
14	43.32	44.06	44.84	45.48	46.12	47.09
28	52.92	54.09	55.42	56.04	57.21	57.77

The percentage increase in the compressive strength of GCC with respect to reference cement mortar (CM1:3) at 7 days, 14 days and 28 days are shown in Figures 6, 7 and 8 respectively.

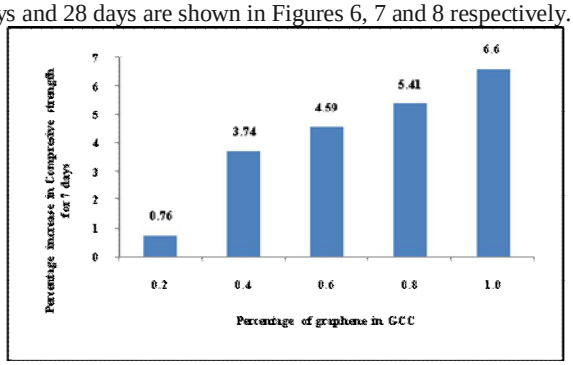

Figure 6. Percentage increase in compressive strength of GCC at 7 days

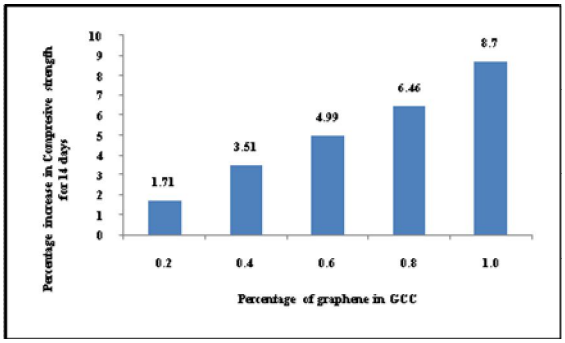

Figure 7. Percentage increase in compressive strength of GCC at 14 days

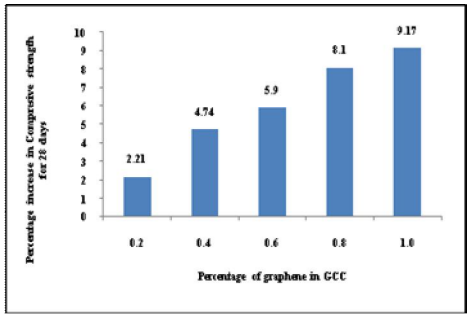

Figure 8. Percentage increase in compressive strength of GCC at 28 days

Table 2 presents the results of flexure test conducted at the end of 28 days. The flexural strength was also found to increase with the increase in graphene content. GCC with 1% graphene recorded the maximum flexural strength. Figure 9 presents the percentage increase in flexural strength of GCC over the flexural strength of reference cement mortar.

Table 2. Flexural strength of GCC

S.No.	Graphene in GCC	Flexural Strength N/mm^2
1	0.0%	150.0
2	0.2%	175.0
3	0.4%	225.0
4	0.6%	287.5
5	0.8%	300.0
6	1.0%	362.5

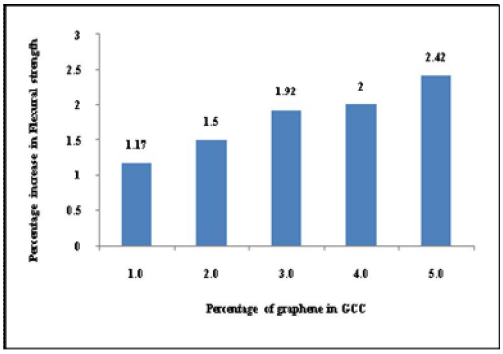

Figure 9. Percentage increase in flexural strength of GCC at 28 days

Table 3 presents the results obtained for split tensile strength and the percentage increase in the tensile strength of GCC (1% graphene) over that of the reference cement mortar.

Table 3. Tensile strength of GCC

S.No.	Graphene in GCC	Tensile Strength N/mm^2	Percentage increase in strength
1	0.0%	60	-
2	1.0%	80	1.33

4. CONCLUSION

Studies made on graphene cement composites using graphene of 0.2%, 0.4%, 0.6%, 0.8% and 1% by weight of cement in cement mortar 1:3 indicate appreciable improvement in the compressive strength, flexural strength and split tensile strength over the normal cement mortar mix. GCC with 1% graphene recorded the maximum strength in compression, flexure and tension over the tested proportions. The nano size of graphene used in GCC reduced the propagation of microcracks and improved the strength of the mortar.

REFERENCES

1. http://www.azonano.com/article.aspx?ArticleID=1872
2. Radu Olar, "Nanomaterials and nanotechnologies for civil engineering," Bulletin of the Polytechnic Institute of Iasi – Construction, Vol. 61, No. 4, pp. 109-117, 2011.
3. Anwar Khitab, Muhammad Tausif Arshad, "Nano construction materials: review," Reviews on Advanced Materials Science, Vol. 38, pp. 181 -189, 2014.
4. Hailiang Wang, Joshua Tucker Robinson, Georgi Diankov, and Hongjie Dai, "Nanocrystal Growth on Graphene with Various Degrees of Oxidation," Journal of the American Chemical Society, Vol. 132, No. 10, pp. 3270-3271, 2010