REVIEW ON PERFORMANCE OF CONCRETE WITH A GRAPHENE OXIDE.

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With Intense Gratitude

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Abstract

The Graphene oxide (GO) is one of the prominent nanomaterial, this has been utilized in the cement composite materials. Graphene oxide represents unprecedented range of properties with a potential to enhance the strength and toughness of cement-based composites. In this study, the influence of graphene oxide was evaluated on the workability, microstructure, strength and durability properties of the fresh and hardened cement composites. Different percentages of graphene oxide were added at 0wt%, 0.01wt%, 0.02wt%, 0.03wt% and 0.04wt% by weight of cement. Workability in terms of fluidity, setting time and viscosity tests were conducted to the fresh GO-cement paste samples. Compressive and flexural strength tests were conducted to the hardened GO-cement paste samples at 28 days.

KEYWORDS

Graphene Oxide
Mechanical Properties
Cement Composites
Workability

INTRODUCTION

Now a day's maximum utilizable and considerable material is cement composite for constructing the concrete structures. It represents an excellent performance towards bonding and strength properties of structures and implemented worldwide. But noticeably still it has been developing with an inherent problem of brittleness, which probably leads to the cracking of cement composites. Characteristically cement composites show an excessive compressive strength but, due to the brittleness property, cement composites are functioning with less tensile and flexural strength. Generally, to improve the tensile or flexural strength of the cement composite various reinforcing substances or materials are used, which includes metal bars steel fibers carbon fibres, polymer fibres and mineral fibres. But with the utilizing of these reinforcing materials brittleness problem was not solved and still occurrence of cracking is happened in cement composites. The hardened cement paste brittleness of cement composite would be generated, which consist of hydration products such as calcium hydroxide (CH), calcium silicate hydrate (C-S-H) gel, and ettringite (AFt), monosulfonate (AFm). Among those hydration crystals, CH, AFt and AFm typically exhibit rod-like and needle-like crystals. Mostly all of the previous toughening strategies concentrated on the various reinforcing substances to improve the tensile or flexural strength of the cement composites and failed to put an attention on the regulation of microstructure, which includes the hydration crystals shape in cement mix. So through the modification of microstructure of the cement paste, the toughness of hardened cement composite can be significantly enhanced and it is a well worth considering technique.

HISTORY

- Graphite oxide was first prepared by Oxford chemist Benjamin C. Brodie in 1859, by treating graphite with a mixture of potassium chlorate and fuming nitric acid. He reported synthesis of "paper-like foils" with 0.05 mm thickness. In 1957 Hummers and Offeman developed a safer, quicker, and more efficient process called Hummers' method, using a mixture of sulfuric acid H_2SO_4, sodium nitrate $NaNO_3$, and potassium permanganate $KMnO_4$, which is still widely used, often with some modifications. Largest monolayer GO with highly intact carbon framework and minimal residual impurity concentrations can be synthesized in inert containers using highly pure reactants and solvents.
- Graphite oxides demonstrate considerable variation of properties depending on the degree of oxidation and the synthesis method. For example, the temperature point of explosive exfoliation is generally higher for graphite oxide prepared by the Brodie method compared to Hummer's graphite oxide, the difference is up to 100 degrees with the same heating rates. Hydration and solvation properties of Brodie and Hummers graphite oxides are also remarkably different.
- Recently a mixture of H_2SO_4 and $KMnO_4$ has been used to cut open carbon nanotubes lengthwise, resulting in microscopic flat ribbons of graphene, a few atoms wide, with the edges "capped" by oxygen atoms (=O) or hydroxyl groups (-OH).
- Graphite (graphene) oxide has also been prepared by using a "bottom-up" synthesis method (Tang-Lau method) in which the sole source is glucose, the process is safer, simpler, and more environmentally friendly compared to traditionally "top-down" method, in which strong oxidizers are involved. Another important advantage of the Tang-Lau method is the control of thickness, ranging from monolayer to multilayers, by adjusting growth parameters.

PREPARATION OF GRAPHENE OXIDE.

Preparation of graphene oxide (GO) by Hummer's method involves the following steps,

(a) Firstly, the mixture of 5 g of graphite + 2 grams of $NaNO_3$ + 30 ml of 98% H_2SO_4 is added to the 50 ml Erlenmeyer flask in ice bath maintaining the temperature below 20°C.

(b) Then, start stirring the mixture for 4 h.

(c) After 4 h of constant stirring measure 5 g of $KMnO_4$ and add slowly to the reaction mixture, and the temperature must be maintained in ice bath while adding $KMnO_4$ because increase in temperature results in explosion.

(d) After adding the $KMnO_4$, stir the mixture for 1 h.

(e) Now remove the ice bath and heat the mixture at 35°C and again stir the mixture for 1 h at this temperature.

(f) Now add 100 ml of double-distilled water stir the mixture well and heat at 95°C for 2 h continuously and do not allow the mixture to boil.

(g) Turn off the heater and allow it to cool in room temperature.

(h) After cooling the mixture, add 300 ml of double-distilled water and stir the mixture for 1 h.

(i) Now add 30 ml of 30% hydrogen peroxide (H_2O_2) solution.

(j) After adding H_2O_2 to the mixture, continue the stirring for another 1 h, thereafter graphene oxide (GO) is formed.

(k) Then, add the 300 ml double-distilled water to the obtained GO and continue the stirring by the probe ultrasonication for increased dispersion of graphene nanoparticles for 1 h.

(l) Then, wash the mixture with 5% HCL and distilled water to get PH7 and filter the graphene oxide (GO) solution.

(m) Finally, the obtained graphene oxide (GO) solution concentration was controlled at 0.4%.

Graphene oxide influence on strength properties and microstructure of cement composite.

For enhancing the improvement in mechanical properties of cement composites, different graphene oxide (GO) dosages of 0.01wt%, 0.02wt%, 0.03wt% and 0.04wt% by the weight of cement, with oxygen content of 28.95%, were incorporated in the cement composites. From the results, it was observed that, the flexural and compressive strength of the hardened cement paste was increased with the gradual increment in the graphene oxide (GO) dosage. At 0.04wt% of graphene oxide dosage with oxygen content of 28.95% the flexural strength was increased by 75% and compressive strength was increased by 46.6% at 28 days of hydration compared with the control sample (without GO).Mostly mechanical property improvement depends on the microstructural condition of hydration crystals in the cement composites. Generally, by microstructural analysis like SEM analysis, microstructure and strength interrelationship of cement mixes would be determined. Figure 4 exhibits that the microstructure of cement composites blended with graphene oxide with 28.95% oxygen content can be observed in SEM images. It was observed from the distinct shape change of hydration crystals in SEM images when the GO dosage is increased gradually. Generally, in the cement composites without graphene oxide (GO) many needles like and bar-like crystals were formed in cranny surfaces, which are the cement hydration crystals of AFt, CH and AFm and jumbled arrangement. Then, due to the incorporation of graphene oxide (GO) content from 0.01wt% to 0.03wt% in cement composites, hydration crystals are formed as an interlinked denser flower-like crystals. As in that way, at the 0.01wt% of graphene oxide (GO) content, only lesser flower-like crystals are formed in the crack surface and the generation of flower-like crystals were stopped. But at the incorporation of 0.02wt% and 0.03wt % of graphene oxide (GO) content, complete flowerlike hydration crystals are formed with enlarged flower petals and well dispersion was done to be distributed uniformly in the cement composites.

LITERATURE REVIEWS

REVIEW OF PREVIOUS STUDIES:
There is little available published data on Review on Performance of concrete with Graphene Oxide. Some of the previous studies or Literature data is presented as below

- SC DEVI AND RA.KHAN 2020 have done Study about Effect of graphene oxide on mechanical and durability performance of concrete and have founded the results in Increase in compressive strength by (21–55%), tensile strength by (16–38%)
- CHANDRA SHEKAR REDDY AND RUBEN NERELLA 2021 have done Study about Enhanced Transport properties of graphene Oxide based cement composite material and have founded the results in Mechanical properties were improved by 77.70% at 0.03% GO in flexural strength and 47.61% at 0.04% GO in compressive strength.
- Chandra Sekhar Reddy Indukuri, Ruben Nerella & Sri Rama Chand Madduru 2020 have done study about Workability, microstructure, strength properties and durability properties of graphene oxide reinforced cement paste and founded results in Viscosity was increased drastically and setting time was decreased, at 0.04wt% of graphene oxide usage, 75% increase in flexural strength and 46.6% improvement in the compressive strength of the cement composites was achieved
- Qureshi, Tanvir, Panesar, Daman.k 2020 have done study about The effect of graphene oxide on the properties of cement based composites and founded the results of The addition of approximately 0.05 wt% of GO to PC paste increased the compressive strength by 15–33%, increased the flexural strength by 41–59%
- S. Nandhini, M. Devasena 2020 have done study about Review on Graphene Oxide Composites have founded the results in GO prevents the growth of bacteria in its surface and hence can be applied to protect construction elements exposed to humidity

METHODOLOGY
Durability Tests and Results on Graphene oxide concrete

Water Absorption Test

The GO incorporation in the cement composite exhibited a greater resistance to water penetration. The maximum resistance was observed at 0.03% GO addition, but at increased GO content of 0.04% resistance to water absorption was decreased, due to the clustering of GO nanosheets in the cement composite increased GO content, but all GO-cement composite mises exhibited a greater resistance to water ab sorption when compared to the conventional sample mixes, results can be observed in Fig. 2. In this study at 0.03% GO addition in cement composite, 14.5% maximum reduction in water absorption was achieved than control sample mixes at 28 days of curing. Mostly due to the extensive barrier properties of GO, the pore structure refinement of cement composite was formed by the reduction in critical pore diameter this leads to the improved resistance to water absorption.

Water Sorptivity Test

The water absorption and passage in cement composite specimens by capillary action is known as the sorptivity. It is one of the durability properties of cement composite and can be determined by finding the rate of capillary rise absorption of water. The maximum resistance was observed at 0.03% GO addition, but at increased GO content of 0.04% the resistance to water sorptivity was decreased, due to the a agglomeration of GO nanosheets in the cement composite at increased GO content, but all GO-cement composite mixes exhibited a greater resistance to water sorptivity than conventional cement composite mixes and results can be observed in Fig. 3. In this study at 0.03% GO addition in cement composite, maximum reduction in water sorptivity coefficient value was achieved at all time intervals than control sample mixes.

Test for Acid attack.

The acidic effect on weight of the both GO-cement composite specimens and normal cement composite specimens was determined at 28 days immersion in acid solutions of both HCl and H_2SO4 with 29% and 5% concentrations. Mostly due to the acidic environment, the pH level of the cement composite was decreased and the cement particles in the void structure could be eaten by the high concentrated acids, due to greater these effects reduction in the weight of the specimens was happened. But, all GO-cement composite mixes with various GO dosages of 0.01%, 0.02%, 0.03%, and 0.04% by weight of cement showed a greater resistance against a reduction in the weight of the specimens than normal t composite specimens. Here the lower weight loss was noticed at water ab- 2% concentrations of both H_2SO4 and HCl acidic solutions than 5% con centration

Test for thermal cycling effect

The thermal resistance of cement composites was examined by find ing the compressive strength of the specimens, which were exposed to a temperature of 100 °C for 8 h in different thermal cycles 3, 7, and 28: days, after that in the remaining 16 h time samples were exposed to room temperature. Thermal resistance was increased in the terms of compressive strength to all GO-cement composite mixes gradually by improving the concentration of GO content from 0.01% to 0.04% by weight of cement when compared to conventional cement composite mixes and the improved results caused due to the pore structure refinement of the cement composite by pore filling nature of the geo nano sheets

CONCLUSION

- The addition of graphene oxide in the cement composite showed an extensive effect on fluidity, viscosity and setting time of the cement paste.
- Compressive strength of a concrete is increases by (21–55%).
- Tensile strength of a concrete is increased by (16–38%).
- Mechanical properties were improved by 77.70% at 0.03% GO in flexural strength 47.61% at 0.04% GO in compressive strength.
- Viscosity was increased drastically and setting time was decreased, at 0.04wt% of graphene oxide usage, 75% increase in flexural strength and 46.6% improvement in the compressive strength of the cement composites was achieved

धन्यवाद

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