

Development of Graphene Oxide on Cement Mortar and Concrete: A Review

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Abstract- *The recent materials used in cement composites are nano materials to improve the mechanical and durability properties of cement composites one such nano material is the Graphene Oxide (GO) adopting this nano material not only improves the existing properties but also bring new properties in to existence. Graphene oxide has drawn much attentiveness for making it fit for the usage as nano-reinforcement material chemical compound due to its extraordinary mechanical properties and active functional groups. This paper mainly focuses at rendering an in depth evaluation on the results of reinforcement and mechanisms of graphene oxide addition on cement composites by referring a group of associated literatures. This analysis produce on crystals clear outcome to understand the reinforcing role of graphene oxide in cement based materials and real time application in construction.*

Keywords- *Durability, Cement composites Graphene Oxide, Nano materials.*

1. INTRODUCTION

After the great fire of London in the year 1666, construction around the world shifted to earthen materials and later to cement from wood. Since then relentless research has been done on construction materials which lead to the invention of concrete. Generally, cement is brittle in nature which leads to cracking when used as a construction material. Many attempts have been made to overcome this challenge, one such attempt is to change the microstructure of the cement by infusing GO. Added benefits of improving the microstructure are increase in tensile and compressive strength, improved resistance to heat, physical and chemical attacks. The paper further discusses about the literature review of GO incorporated cementitious materials, its applications and challenges. Further research gap has been analyzed and conclusions are drawn based on thorough research.

2. LITERATURE REVIEW

Graphene oxide is used in various forms depending upon the purpose like GO as nano reinforcing material to improve the tensile strength, GO nano platelets to improve the pore structure of cement, GO as repair material in structural elements etc., The following the research on Graphene oxide incorporated in cementitious materials over the past few years.

Chandra Sekhara et al. 2019 presented that GO improved the pore filled nature of the cement mortar which resulted in improved mechanical properties. He conducted XRD on cement composites to identify the crystalline materials and its phase composition.

Mohammed et al. 2017 Investigated the effects (GO) in conventional and HSC various temperatures.

Thermal deformation of concrete specimens with GO was compatible and shows no early negative expansion. Anti spalling behavior was seen in HSC with GO, while the concrete without GO shows high spalling. GO's networks of micro channels and reinforcing effects helps in water vapour release.

S.C devi et al 2019 Investigated the effect of graphene oxide on concrete mechanical and durability properties. By increasing GO percentage (0%, 0.02%, 0.04%, 0.06%, 0.08%) with respect to cement weight in a certain dosages we can observe there is a certain amount of change in Mechanical (Tensile, Compressive & Bending Strength) Properties & Durability (sorptivity, Permeability) Properties. We can compare above properties with respect to other design mixes without GO content. We can observe at 0.08% it shows Good results compared to other % GO content. The micro structure of GO are studied by FE- SEM/EDX, FT-IR and XRD.

Sam Ghazizadeha et al. 2018 This paper reports on the influence of graphene oxide on the hydration of cement and clinker. Graphene oxide increases cement hydration and retards the setting time of clinker. The rate of hydration increases due to nano size particles with more specific surface area and the retardation of clinker due to the interaction of GO with surface of hydrating grain.

3 MECHANISM OF GO IN CEMENT COMPOSITES

3.1 Effect of GO on the workability of the cement paste and mortar

The influence of Graphene oxide addition on cement paste workability:

The graphene oxide alters the properties of cement paste such as fluidity, viscosity, setting time. Upon the continuous increase in dosage of GO, it results in decrease in the fluidity nature of cement paste and thereby viscosity increases with decrease in setting time of cement paste due to increase in rate of hydration. The clear results can be seen at the dosage of 0.03% graphene oxide. The changes in fluid nature and viscosity are the minute nano size effects. Due to the existing basic chemical nature of graphene oxide as it is having much functional groups on the large surface area and at the edges and it will be resulting in increase in rate of hydration and thereby decrease in the setting time of cement paste. The decrease in setting time is also limited to 0.5 hour or 30 min, which is in the limit of code provisions.



3.2 Effect of GO on the hydration heat of cement

The heat of hydration of cement decreases in the initial 3 days duration and thereby level off thereafter. At Graphene Oxide addition of 0.02%, the rate of heat evolution and the total amount of heat evolution have suddenly decreased over 50% been observed. Even though the increase in dosage of graphene oxide will result in the rate of heat evolution and total amount of heat evolution gradually decreases and level off with the dosage of graphene oxide only. Generally to reduce the heat of hydration the addition of silica fume or fly ash may be recommended but here the mechanism in addition of graphene oxide is to hinder the time at which peak heat releases. The main principle for addition of graphene oxide in heat of hydration point of view is as Graphene oxide is having the GO has high specific surface area & also contain oxygen molecules. These O₂ group compounds act as a catalyst in hydration of cement paste in concrete and also reduces the heat of hydration. At initial stages of hydration process GO prevents the formation of gel pores & total pores, so we can say by reduction in total volume of pores durability criteria can be achieved.

3.3 Effect of GO on the mechanical strength of the hardened cement paste and mortar

The impact of graphene oxide addition at different levels in the hardened cement paste and cement mortar in mechanical strength point of view as follows. When there is an increment in Graphene oxide dosage, it will result in the increase of compression and flexural strength of hardened cement paste. When the graphene oxide is 0.05%, the bending strength increases by 86.1, 68.5, 90.5 percentages and whereas increase in the compressive strength of hardened cement paste is 52.4, 46.5, 40.4 percentages at the 3 days, 7 days, 28 days respectively. When it is observed on hardened cement mortar the results are as follows. When the amount of GO is 0.05%, the flexure strength increases by 69.4, 106.4, 70.5 percentages and whereas increase in the compressive strength of hardened cement mortar is 43.2, 33, 24.4 percentages at the 3 days, 7 days, 28 days respectively. But, more surely it is observed that it has crystal clear effect on the bending strength than the compressive strength.

3.4 Surface morphology and texture structure of the hardened cement paste

The influence of graphene oxide on structure morphology and texture of hardened cement paste is as follows. With increase in the percentage of graphene oxide content can increase in the cement it is resulting in the formation and increase in amount of flower like crystals and thereby mitigation in the harmful pores & structure become more compact than earlier. This event elucidates us that as the increase in graphene oxide content can stimulate the hydration of cement paste and render more crystals which upgrades the crystalline structure limitations and come up with increase of bending and compressive strengths.

3.5 Effect of GO on the pore structure of the hardened cement paste

The pore structure of the hardened cement paste has appreciable effects on the strength, durability and shrinkage. In the sample mainly transitional pores and gel pores are present. The pores which are greater than 50 nm

are referred as macroscopic pores and which contribute to strength and durability.

The pores which are less than 50 nm are referred as microscopic pores and which may have the effect on creep and dry shrinkage. The influence of Graphene oxide incorporation on the total pore volume distribution of hardened cement paste at 3, 7, 28 days as follows. At 3 days, cumulative pore volume with various graphene oxide contents showed no significant changes except in the case of the pore size which is 3 nm which is considered to be the pores between C-S-H layers. At initial stages of hydration process GO prevents the formation of gel pores & total pores, so we can say by reduction in total volume of pores durability criteria can be achieved.

4. APPLICATIONS

- One of the most significant properties of cementitious materials is Durability, particularly for structures presented to severe conditions and forceful condition. Graphene nano platelets improve strength by improving resistance of the mortar to penetrability, chloride diffusion and chloride dispersion coefficient.
- GO infused in regular and HSC has high resistance under high temperature. As it helps in channels formation at all scales, which helps to prevent extensive spalling by releasing vapour pressure.
- Increase Yield stress of cement matrix are increased by addition of Graphene Oxide admixture.
- Increased plastic viscosity of mortar with GO is observed.
- Improves interfacial bonding between cement matrix and fiber reinforcement.
- Refines the pore structure thereby improving the total porosity of the cement matrix, making the matrix more compact.
- Increase in the surfactant influence on freeze thaw resistance.
- It increases the mechanical properties of concrete

5. CHALLENGES

Some of the practical problems for the infusion of GO in cement composites are

- Presently, Production of GO in huge quantity is not possible.
- Dispersion of GO in cement composites in large quantities is difficult.
- GO reduces workability of cement composites (Less than 10 percent)

6. RESEARCH GAP

1. To improve the concrete mechanical and durability properties, A lot of research is required with addition of graphene oxide as a nano material.
2. Till now the research has done extensively in cement mortar infused GO the research has to be done on GO infused special concrete to study mechanical and durability properties. Further study pull out test, flexural behaviour, sulphate attack and permeability test.

7. CONCLUSIONS

Infusion of Graphene oxide (GO) as a cementitious material showing improvement in both properties and also performance. This summary is concluded from finding out the report of literature survey for GO based upon the cementitious materials.

1. This GO improves the microstructure study of cement that reducing the capillary pores & increasing gel pore structure.
2. As of the microstructure is improving hydration of cement that enhances the results that is improving the mechanical strength.
3. The chloride penetration is more effectively inhibiting in cement with graphene oxide as the capillary pores are reduced.
4. Incorporating the GO in cement paste with different proportions shows different strength values ranges in between (0.01 % -0.03% wt of cement) showing an increasing in increment of flexural strength about 43%.
5. Incorporating the GO in cement paste with different proportions shows different strength values ranges in between (0.01 % -0.03% wt of cement) showing an increasing in increment of compressive strength about 29% to 55%.
6. Incorporating the GO in cement paste with different proportions shows different strength values ranges in between (0.01 % -0.03% wt of cement) showing an

increasing in increment of Tensile strength about 16% to 38%.

7. Due to GO's there has large surface area that absorb more water which is mainly effect the workability

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