ABSTRACT

Graphene oxide (GO) is a derivative of graphene, which has a single layer of carbon atoms arranged in a two-dimensional honeycomb lattice. Each carbon atom's bonding within this is hybridized sp^2 with the inclusion of π-orbitals. Each graphene unit cell contains two orbitals that are scattered to form two bonds, each of which might be referred to as bonding and antibonding. Over the past few decades, GO has drawn attention for its use as a reinforcing element in cement-based construction materials. There are very limited studies on the effect of GO addition in cement based materials. Previous studies indicate the GO addition in cement along with different types of dispersing agents or chemicals and minerals. Thus, an attempt has been taken to use GO without such chemicals or minerals in cement sand mortar using two different types of cement such as Ordinary Portland Cement (OPC) and Portland Pozzolana Cement (PPC). The mechanical strength, durability, and micro-structure properties of mortar having the cement-sand ratio of 1:2 and 1:3 (by weight) with and without GO have been studied experimentally. The different proportions of GO (0.03–0.06% by weight of cement) were incorporated into the cement mortar matrix. The water-to-cement ratio was fixed at 0.45.

The uniform dry mixing of GO in cement mortar is quite difficult. The GO nanoparticles tend to agglomerate and form clusters in the presence of water due to their hydrophobic nature and strong Van der Waals interactions between individual nanoparticles. Thus, the most significant process for uniform mixing of GO in cement composites is the sonication of GO with water and subsequent addition in the matrix. During sonication, it breaks down the agglomeration and promotes dispersion and exfoliation. In this present study, GO was mixed with water at a ratio of 1:200 (by weight), and it was sonicated for 45–60 minutes using a UP100H ultrasonic processor, no additional chemicals or dispersion agents were used.

The results of the flow table test indicated that for all types of mortar mixes using either OPC or PPC, the workability in terms of the final flow diameter of the flow table is reduced with the

addition of GO compared to the control mortar mix (without GO). The maximum reduction was noted with the addition of 0.03% of GO for all mixes. In general, the addition of GO increases the compressive strength of the OPC or PPC based cement sand mortar up to an optimum limit. This is due to the filling up of nano pores and the GO acts as nanofibers within the matrix arresting the initial micro cracks as per microstructural study. The optimum amount of GO in terms of maximum compressive strength was 0.05% and 0.04% by weight of cement, for OPC and PPC based cement-sand mortars, respectively. The flexural and split tensile strength of such mortars show similar results. The Young's modulus of OPC or PPC based cement-sand mortar is also enhanced with the addition of a small amount of GO.

The durability study also indicated that the optimum amount of GO addition in the cement-sand mortar was 0.05% and 0.04% by weight of cement, for OPC or PPC based cement-sand mortars as in the case of strength. The rate of water absorption of GO modified OPC or PPC based cement mortar was lower than the control sample. Similarly, the amount of charge passing through the specimens in the RCPT test was found lower for GO modified cement mortar. However, the GO modified OPC and PPC based cement-sand mortar have almost similar resistance against acid attack for a limited period of 56 days compared to the control.

The MIP test result of OPC and PPC based cement mortar confirmed that the incorporation of the optimum amount of GO, by filling of large pore area reduces the total pore volume and refines the pore structure of cement mortar. The results of XRD analysis reported that the formation of more C-S-H gel in GO based cement mortar both in OPC or PPC with respect to their corresponding control mortar. As per the FESEM test, a distinct change in the morphology of GO modified OPC or PPC based cement mortar is detected as compared to their corresponding control where the former had a large amount of denser crystal. The elemental analysis by EDX indicated that the percentages of carbon atoms and silicon atoms in cement mortar changed noticeably with the addition of a small amount of GO.

Although, the addition of appropriate amount GO to cement-sand mortar enhanced the strength and durability, but long-term effects are not studied. The optimum limit for the cement sand mixture will change depending on the mix proportion and the chemical composition of GO. Despite its high cost, wider applications of GO in different fields will definitely reduce the price over time.