Design and synthesis of graphene/silica hybrid additives for the fabrication of thermally enhanced grout mixtures

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Shallow Geothermal Energy Systems have attracted enormous research interests owing to its several advantages such as reducing CO_2 emission, being weather independent despite of other renewable energy technologies and availability in most of fields. One of the most significant issue in geothermal heat exchangers is to preserve the heat of ground stable through the boreholes without temperature difference. Grouting material plays a significant role such as transmitting the heat to the pipes through the ground. Therefore, the thermal conductivity of the grout that covers the pipes should be maintained properly. At this point, carbon based materials such as graphene and expanded graphite are good candidate to reduce heat loss due to their remarkable thermal properties and low density and its planar geometry. There are several work about the enhancement of thermal conductivity of cement by the incorporation of carbon based thermal conductive materials. However, dispersion of carbon materials and their high water demand are main bottlenecks to attain high performance cement. Therefore, surface modification is required to increase surface hydrophilicity to increase interfacial interactions between the chosen carbon material and cement matrix. In the present work, hybrid carbon/silica additives were developed by making bridges using silane coupling agents which have a significant influence on particle size and its dispersion in the matrix. In order to obtain homogeneous dispersion in water-based solutions, carbon/oxygen ratio of carbon materials and their polarity carries significant importance. Two different carbon sources, graphene nanoplatelet (GNP) produced by recycling and upcycling processes from waste tire and expanded graphite (EG), were used to evaluate their influence on thermal conductivity of the produced grout mixtures. Both GNP and EG based silica hybrid additives were characterized by spectroscopic, gravimetric and macroscopic techniques to confirm the structural formation. Hybrid additives were incorporated into grout mixtures at the loading changing 1 wt% to 5 wt% to monitor the changes in thermal conductivity. Produced hybrid additive enhanced the thermal conductivity of the grout and thus provide to increase the efficiency of the heat transmission and prevent the aggregation of treated hybrid additives in grout mixture.

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