Investigation of Physical Properties of Graphene Nanoplatelet Cement in Concrete Elements Susceptible to Cracking

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ABSTRACT

Thermal and autogenous cracking in concrete elements is a serious issue which triggers corrosion and carbonation of contained steel and as result destruction of concrete members. Extensive restrained shrinkage ring experiments results of mortar specimens prepared with cements at varied phase compositions and finenesses indicate that interaction of C_3A and sulfate source is the prime phenomena influencing concrete cracking followed by cement fineness as the second main factor. Determination of thermal diffusivity of graphene cement paste using Linseis (C) XFA500 instrument indicates that samples prepared with graphene (up to 10% by weight) as a partial replacement of cement show over 70% improvement of thermal diffusivity. Improved diffusivity results in better cement heat of hydration dissipation and as a result reduction of temperature gradient and thermal cracking in mass concrete elements. Measurement of heat of hydration of graphene cement paste, at (w/c)=0.5, using TAMAIR isothermal conduction calorimetry indicates that incorporation of graphene up to 10% by weight increases the length of induction period while reduces the height of alite main heat flow peak due to filler effect of graphene particles in hardening graphene cement paste. Isothermal conduction calorimetry heat flow curves show that incorporation of graphene up to 10% does not have significant impact on interaction of C_3A and sulfate source since the time of occurrence and location of C_3A main heat flow peak corresponding to depletion of sulfate source are not affected for samples prepared with varied graphene contents. Full factorial statistical design and analysis method conducted on compressive strength of mortar samples prepared at varied (w/c), cement finenesses and graphene amounts indicates that 1- quantity of graphene and 2- physical interaction of (w/c), graphene and cement fineness, have the smallest P-Value among all the samples, demonstrating the most significant impact on compressive strength of mortar samples.