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Effects of Supplementary Cementitious Materials on Early Age Thermal Properties of Cement Paste

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Abstract : Cement hydration is an exothermic chemical reaction generally leading to a rise in concrete's temperature. This internal heating of concrete may, in turn, lead to a temperature difference between the hotter interior and the cooler exterior of concrete and thus differential thermal stresses in early ages which could be particularly significant in mass concrete. Such differential thermal stresses result in early age thermal cracking of concrete when exceeding the concrete's tensile strength. The extent of temperature rise and thus early age differential thermal stresses is generally a function of hydration heat intensity, thermal properties of concrete and size of the concrete element. Both hydration heat intensity and thermal properties of concrete may vary considerably with variations in the type cementitious materials and other constituents. With this in mind, partial replacement of cement with supplementary cementitious materials including fly ash and ground granulated blast furnace slag has been investigated widely as an effective strategy to moderate the heat generation rate and thus reduce the risk of early age thermal cracking of concrete. However, there is currently a lack of adequate literature on effect of partial replacement of cement with fly ash and/or ground granulated blast furnace slag on the thermal properties of concrete. This paper presents the results of an experimental conducted to evaluate the effect of addition of varying percentages of fly ash (up to 60%) and ground granulated blast furnace slag (up to 50%) on the heat capacity and thermal conductivity of early age cement paste. The water to cementitious materials ratio is kept 0.45 for all the paste samples. The results of the experimental studies were used in a numerical analysis performed using Comsol Multiphysics to highlight the effects of variations in the thermal properties of concrete, due to variations in the type of aggregate and content of supplemenraty cementitious materials, on the risk of early age cracking of a concrete raft.

Keywords : thermal diffusivity, early age thermal cracking, concrete, supplementary cementitious materials
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