The Filler Effect: The Influence of Filler Content and Surface Area on Cementitious Reaction Rates

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Abstract

Inorganic mineral fillers are known to accelerate cement hydration rates. This *filler effect* has been attributed to the effects of dilution (i.e., *w/c* increase) or to the provision of additional nucleation sites by fine powders. Through extensive experimentation and simulation this paper describes the influence of surface area and mineral type (i.e., quartz or limestone) on cement reaction rates. Simulations using a boundary nucleation and growth (BNG) model indicate that the extent of the acceleration is linked to the: (1) surface area increase and (2a) the capacity of the filler's surface to offer favorable nucleation sites for hydration products. Other simulations implemented using a kinetic cellular automaton model (HydratiCA) suggest that accelerations are linked to: (2b) the interfacial properties of the filler which alters (increases or decreases) its tendency to serve as a nucleant and (3) the composition of the filler and the tendency for its ionic constituents to participate in ion exchange reactions with the calcium silicate hydrate product. The research correlates and unifies the fundamental parameters that drive the filler effect and provides a detailed mechanistic understanding of the influence of filler agents on cementitious reaction rates.

Keywords: cement, limestone, quartz, hydration, modeling and simulation