Physics Colloquium

Michigan Technological University
Thursday, October 4, 2012
4:00 pm
Room 139 Fisher Hall

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

Gaurav Sant
Department of Civil and Environmental Engineering
University of California, Los Angeles, California

Abstract: Finely ground mineral powders are known to accelerate cement hydration rates. This "filler effect" has been attributed to the effects of dilution (w/c increase) when the cement content is reduced or to the provision of additional surface area by fine powders. The latter contribution (i.e., surface area increase) is speculated to provide additional sites for the nucleation of hydration products, which accelerates reactions. 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 and a multiphase reaction ensemble (MRE) model indicate that the extent of the acceleration is linked to: (1) the magnitude of surface area increase and (2a) the capacity of the filler surface to offer favorable nucleation sites for hydration product. Other simulations 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 components to participate in ion exchange reactions with the calcium silicate hydrate product. The simulations are correlated with the accelerations observed using isothermal calorimetry when fillers partially replace cement. The research correlates and unifies the parameters that drive the filler effect and provides a detailed mechanistic understanding of the influence of filler agents on cementitious reaction rates.

Biography: Gaurav is an Assistant Professor and holder of the Edward K. and Linda L. Rice Endowed Chair in Materials Science in the Department of Civil and Environmental Engineering and a Member at the California Nanosystems Institute at the University of California, Los Angeles. He earned his BSCE (2006), MSCE (2007) and PhD (2009) in Civil Engineering from Purdue University and spent a post-doctoral year (2010) as a Research Scientist at the Ecole Polytechnique Federale de Lausanne. Gaurav has authored or co-authored over 35 papers in international journal and conference publications. He has been involved in the development of crack-resistant concretes, methods for measuring deformations and stresses in early-age concrete and techniques to identify the fluid-to-solid transition in cementitious systems. His current research is focused on the development and application of quantum chemical, thermokinetic and geochemical analyses and simulations to design and proportion binder systems with a greatly reduced cement content and low-CO_2 footprint. These efforts are directed to formulate the next generation of materials and methods to enable sustainability in concrete construction applications.

MichiganTech