Center for Infrastructure Engineering Studies

research seminar

Understanding Reaction Processes and Composition-Structure-Property Relations in Traditional and Novel Sustainable Cementitious Formulations

Concrete is the most used man-made material in the world. The drive to produce more sustainable concrete materials is leading to more complex mix designs that include increased amounts of secondary mineral additions/substitutions, often originating as by-products of other industrial processes, and a wide variety of chemical admixtures to enhance concrete performance and reduce cement use. This study describes methods to correlate the chemistry and composition of the solid precursors, the solution chemistry and the progress of reactions to their imposition on the evolution of mechanical properties and durability characteristics. To achieve this unification, this research applies a hierarchical sequence of experiments and numerical simulations to develop sustainable cementitious formulations, which leverage cement, limestone, fly ashes and/or other admixtures being strategically added to tailor reaction behavior and, ultimately, performance.

Biographical Sketch

Dr. Aditya Kumar is a Materials Scientist, specialized in chemistry of construction materials, with strong interest in employing numerical and experimental methods to identify and develop composition-structure-property relations. Dr. Kumar currently works as an Asst. Professor in the Dept. of Materials Science and Engineering at Missouri S&T. Before this, he was a Project Scientist in the Department of Civil and Environmental Engineering at UCLA. He has worked on the development of a microstructure based multi-phase kinetic and geochemical modeling platform to simulate hydration, microstructural evolution and continuum phase equilibria in cement-based systems. Recent efforts are focused on the application of vertical scanning interferometry to describe the reactivity of minerals and cement phases in solutions of varying chemistries and the development of numerical models which describe early dissolution processes of minerals. These efforts provide guidance to develop simple toolkits to correlate material proportions, reactions and property development in traditional and “cement-free” binder materials.
Concrete made with portland cement is the most widely used construction material. However, concrete can present some disadvantages, such as delayed hardening, low tensile strength, relatively high drying shrinkage and low chemical resistance. Polymer-modified concrete (PMC) is an alternative material that has been employed in construction applications. PMC is made by modifying ordinary concrete with polymer additives, such as latexes, redispersible polymer powders, water-soluble polymers or liquid resins. The aim of this study is to investigate the effect of cost-effective polymers, namely polyurethane (PU) and poly (vinyl alcohol co-ethylene) (PVACE) in improving the flexure strength and compressive strength of portland cement concrete. The coarse aggregate was precoated with either PU or with PVACE polymer prior to its placement in a cement matrix. The effect of different polymer contents was measured for treatment levels of between 30% to 100% of treated aggregate for PU or from 2 to 30 mg/m2 mass of PVACE per aggregate surface area. The results indicated that the incorporation of 12 mg/m2 of PVACE lead to an increase in the flexure strength of concrete of approximately 12%.

**Biographical Sketch**

Dr. Thomas Schuman is a Professor of Chemistry that specializes in interfacial spectroscopy and chemistry and polymers & coatings. His research interests include organic coatings, formulated from custom-synthesized polymers, applied to metal or plastic substrates. Interfacial chemistry is then probed using spectroscopic and wetting analyses. Structure-property relationships of the adhesive interface are defined using microscopic, tensile adhesion, and corrosion analyses. His goals are to characterize adhesion and corrosion phenomena on metals and adhesion to plastics.