ABSTRACT

Nanomechanical Properties of Cementitious Materials

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Although cementitious construction materials are mainly used in a large scale and in huge quantities, fundamental properties such as strength, ductility, creep, shrinkage, and fracture behavior depend, to a great extent, on structural elements and phenomena which are effective at the micro- and nanoscale. This research involves characterization of the micro- and nanoscale properties of cementitious materials using various imaging techniques and evaluation of local mechanical properties. A systematic sample preparation technique developed in this work enabled the investigation of the microstructure and nanostructure of cement paste using atomic force microscopy and a novel nanoindentation technique. An in-depth study on the effects of curing age, water to cement ratio, and micro- and nano-modifiers on the nanomechanical properties of concrete was performed. Furthermore, this study examined experimentally the nanomechanical properties of the interfacial transition zone (ITZ) in concrete. Despite the difficulties associated with the complex nature of the ITZ, this dissertation reports one of the first, most comprehensive endeavors to successfully measure its local nanomechanical properties. Additionally, the effects of silica fume and nanosilica additives on bulk paste were investigated. The ultimate goal of this research is to control the macroscopic properties and develop new materials with improved properties. Findings from this work will lead to a better understanding of the complex macroscopic phenomena and also provide input for multiscale modeling.