Ultra-High Performance Concrete with Tailored Properties

Cementitious materials comprise a large portion of domestic structures and infrastructure. The development of ultra-high performance concrete (UHPC) is a key technological thrust in the design of next generation infrastructure materials with tailored properties. Ongoing research on UHPC, which has a hierarchical structure consisting of a cementitious matrix, finely divided mineral aggregates and metal, mineral, or polymer fibers, emphasizes the synthesis of multiscale modeling and simulation-based materials design.

Microstructure at various scales control the performance of these materials. A nano-micro-meso scale cohesive finite element method (CFEM) capability for cementitious materials is used to identify and characterize transformational, dissipative, and hardening mechanisms to enable the design of hierarchical micro-/meso-structures to improve the response of buildings or structures to dynamic loading and fire.
Upscaling and Translational Research

Successfully bringing the benefits of UHPC produced in the laboratory to the field has been the focus of multiscale experimental research in Lawrence Kahn’s and Kimberly Kurtis’s groups in Civil and Environmental Engineering. Their research has demonstrated that UHPC can develop comparably high strength with longer, more moderate temperature curing regimes achievable in practice, and that tensile creep capacity of UHPC sufficiently allows for elimination of transverse reinforcement in prestressed bridge girders. Research in Civil and Environmental Engineering has also brought new understanding of shear and shear friction phenomena and the potential for anisotropy due to fiber alignment in UHPC, while also addressing the applicability of existing codes and design equations for shear performance at interfaces between UHPC girders and cast-in-place bridge decks. Current research production of UHPC focuses on locally available materials and conventional mixing practices.

Full scale testing of UHPC girder and cast-in-place normal strength concrete bridge deck at Georgia Tech’s Structures and Materials Laboratory in the School of Civil and Environmental Engineering.