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Innovations in Advanced Materials for Sustainable Construction

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Extended Abstract

This keynote highlights recent advances by the author's research team in developing and implementing innovative advanced materials for sustainable construction. The work spans material characterization, numerical modeling, and structural performance evaluation of reinforced concrete (RC) members incorporating nonmetallic fibers, recycled aggregates, geopolymer-based mortars, and non-corrosive fiber-reinforced polymer (FRP) reinforcement. Studies on recycled concrete aggregates (RCA) show that untreated RCA can reduce concrete performance; however, incorporating nonmetallic macro-fibers helps mitigate tensile property losses and enables the formulation of new tensile softening laws that capture the post-cracking behavior of RCA-based fiber-reinforced mixtures. Complementary research on FRP-reinforced concrete addressed durability, the structural behavior of continuous members, and the performance of disturbed regions. Findings revealed that durability depends strongly on void content and moisture uptake, and that hybrid steel-FRP reinforcement enhances serviceability. Parallel efforts on cement-free repair systems using nonmetallic fabric reinforcement and geopolymeric matrices led to the development of new bond-slip models and validated numerical tools for predicting the structural response of strengthened RC members. These systems achieved performance comparable to traditional cement-based composites while offering environmental benefits. Collectively, these advances support circular-economy principles, extend service life, reduce carbon emissions, and provide practical pathways for sustainable and resilient infrastructure.