ENHANCING CEMENTITIOUS COMPOSITES THROUGH WASTE VALORIZATION: THE EFFECT OF MULTISCALE RECYCLED MATERIALS ON THE PROPERTIES OF MORTARS

Master's Thesis By: Aniya Edwards

To Be Presented: April 15th, 2025, 9AM-11AM

Advisory Committee: Dr. Mirian Velay-Lizancos (Co-Chair), Dr. Jan Olek (Co-Chair), Dr. Raikhan Tokpatayeva (Member), Dr. Antonio Bobet (Member)

ABSTRACT

Extending the service life of concrete has become a key goal to maintain the development of built environments accommodating a growing population. An effective way to improve construction sustainability is to enhance the durability of cementitious composites by valorizing waste. This master's thesis evaluates the use of two alternative waste materials—recycled textile fibers (RTF) and nano-recovered carbon black (RCB)—in cementitious composites to enhance their durability and reduce the use of raw materials in construction. The document includes two studies highlighting the role of water in their performance. The first study examines how moisture content affects the degree to which RTF influences the thermal and mechanical properties of RTF-reinforced mortars. The performance of mortars reinforced with varying RTF contents (0%, 0.5%, 1%, and 2% by aggregate volume) were analyzed in both dry and saturated states. While RTF incorporation reduces the mortar's strength, it mitigates crack propagation and prevents immediate collapse after failure, especially when saturated. Mortars with RTF also have smaller strength differences between dry and saturated conditions than the reference mortars. Additionally, RTF incorporation also increases thermal efficiency in mortars by reducing conductivity. Higher moisture content generally increases conductivity, but the conductivity of saturated RTF mortars is lower than saturated reference mortars. The second study evaluates RCB, a rubber byproduct, as an additive for cementitious composites and how water-to-cement (w/c) ratio influences its effectiveness. Mortars and pastes with 0.42 and 0.48 w/c were mixed with 0%, 0.5%, 1%, and 2% RCB content by weight of cement, and were tested to evaluate their hydration kinetics, mineralogical development, and strength development. Results showed that RCB performs best at lower w/c ratios, particularly in early-age strength development. This is supported by increased hydration products found within 3 cm of the surface of early age, low w/c RCB pastes. The study highlights the importance of taking special considerations on mix design when using RCB, due to its hydrophobic and clustered nature. These studies contribute to the foundational knowledge on the role of waste materials in sustainable and durable construction.