Effect of Polyvinyl Alcohol Fiber Content on the Frost Resistance of Recycled High-Ductility Cementitious Composites

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Abstract

Freeze–thaw damage poses a significant durability risk for recycled high-ductility cementitious composites (R-HDCC) in cold regions. This study investigated the influence of polyvinyl alcohol (PVA) fiber content (ranging from 0.306% to 1.512%) on the frost resistance of R-HDCC. After 300 freeze–thaw cycles, the mass change, relative dynamic modulus of elasticity (RDEM), residual compressive and flexural strength, and direct tensile stress-strain behaviour of R-HDCC were tested. Scanning electron microscopy observations of the fracture surfaces were conducted to elucidate cracking characteristics and interfacial damage mechanisms. Results showed that all mixtures exhibited an apparent mass gain during the early exposure stage due to water absorption. With prolonged testing, surface scaling and progressive degradation became dominant, leading to measurable mass loss. Relative dynamic modulus of elasticity (RDME) was more sensitive than mass change in detecting internal freeze-thaw damage. Mixtures with 1.0-1.5% PVA showed the best freeze-thaw resistance, with lower mass loss and higher RDME retention. The 28-day compressive and flexural strengths increased with PVA fiber content up to 2.0% and slightly decreased at 2.5%. The 2.0% PVA mixture also exhibited the highest tensile strain capacity and strain energy density. Moderate PVA contents improved crack bridging and fiber pull-out resistance, while excessive fiber addition increased local heterogeneity and interfacial defects.

Keywords

Frost Resistance, Recycled High-ductility Cementitious Composites, Freeze-Thaw Cycles, Polyvinyl Alcohol Fiber