Mechanical Performance Assessment of Rubber Fiber–Modified Reinforced Concrete

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Abstract

The global accumulation of waste rubber tyres poses serious environmental and health challenges, with around ten million tyres discarded annually and large quantities illegally dumped. Sustainable recycling strategies are therefore essential. Incorporating recycled rubber fibers (RRF) into concrete offers a promising solution, enhancing mechanical performance while promoting a circular economy. This study evaluates the effects of RRF on the fresh and mechanical properties of concrete. Mixtures with 0%, 3%, 6%, 9%, and 12% RRF were produced using water-to-cement (w/c) ratios of 0.40, 0.45, and 0.50. Fresh and hardened properties were assessed, including slump, density, compressive strength, splitting tensile strength, flexural strength, water absorption, and volume of permeable voids at 28 and 184 days. Results indicate that increasing RRF reduced slump and fresh density across all w/c ratios, with wet density decreasing by 28%, 19%, and 14% at 0.40, 0.45, and 0.50 w/c, respectively, as RRF increased from 0% to 12%. Compressive strength decreased with higher RRF content; at 0.40 w/c, 28 - day strength reduced from 61.80 MPa (0% RRF) to 2.20 MPa (12% RRF). Notably, 6% RRF achieved compressive strengths within structural limits (30 MPa for 0.40 and 0.45 w/c and 20 – 25 MPa for 0.50 w/c). Splitting tensile strength increased from 0% to 3% RRF at 184 days (3.73 MPa at 0.40 w/c and 4.03 MPa at 0.45 w/c) and gradually decreased beyond 6%, which remained comparable to the control. Flexural strength decreased with RRF but maintained a strength of 4 MPa at 6% across all w/c ratios. Water absorption and permeable voids increased with higher RRF content due to the fibers' low density and limited bonding with cement and aggregates. Overall, 6% RRF was identified as the optimal fiber content across all w/c ratios, balancing workability, strength, and sustainability, and demonstrating suitability for structural concrete applications.

Index Terms

Circular Economy, Fresh Properties, Mechanical Properties, Rubber Fibers, Structural Concrete