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Article

Damage Monitoring in Recycled Aggregate Concrete Reinforced with Hybrid Steel–Polyolefin Fibers Using Acoustic Emission Technique

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Highlights

What are the main findings?

- The low-cost acoustic emission technique has been shown to be an effective non-destructive method for monitoring damage progression.
- The hybrid (steel and polyolefin) fiber reinforcement enhanced the mechanical properties and crack resistance of recycled aggregate concrete.

What are the implications of the main findings?

- The composite mixture consisting of 50% steel and 50% polyolefin fibers achieved the highest tensile and flexural strength of recycled aggregate concrete.
- The b-value analysis was a sensitive indicator of damage evolution and failure behavior.

Abstract

The mechanical properties and real-time damage evolution of sustainable concrete (SC) containing 100% recycled concrete aggregate (RCA) under the combined action of hybrid steel and polyolefin fibers were studied. Inspired by solving the massive effects on the environment from construction waste, as well as to improve the lower mechanical performance of lower-grade RCA, the effect of combining high-stiffness hooked-end steel fibers and flexible macro-polyolefin fibers within RCA was investigated. Six different mix designs were considered: plain, single-fiber (100% steel and 100% polyolefin) and three hybrid composites with varying fractions of the steel/polyolefin fibers (25/75, 50/50, and 75/25). Compressive, tensile and flexural strengths were determined by mechanical testing. During compressive testing, the damage evolution was monitored using low-cost acoustic emission (AE) as a non-destructive technique. Cumulative hits analysis, amplitude distributions, and the statistical b-value parameter were used for damage characterization. The results show that steel fiber significantly increased compressive strength (an increase of up to 13.8%), and the 50/50 hybrid mix showed a high synergistic effect, yielding the highest tensile (4.86 MPa) and flexural (25.54 MPa) strengths. AE analysis identified different damage fingerprints: Based on amplitude analysis, steel-fiber composites exhibited high-amplitude events (which may be attributable to fiber pull-out); polyolefin-fiber composites generated medium-amplitude events (may have resulted from distributed microcracking); and hybrid mixes displayed a mixed amplitude distribution. The b-value analysis provided insight into progressive damage and revealed that the hybrid fibers induce stable, diffuse damage

Academic Editor: Hyun-Do Yun

Received: 23 March 2026
Revised: 20 May 2026
Accepted: 8 June 2026
Published: 21 June 2026

 https://doi.org/10.3390/fib14060076