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Fracture Behaviour of Rubber- and Silica Nanoparticle-Toughened Glass Fibre Composites under Static and Fatigue Loading

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Abstract

The crosslinked polymers used in fibre composites are very brittle, and require toughening for structural applications. Research over many years has increased the fracture energy, but the fatigue resistance of these toughened polymers is very poor, limiting the optimisation of structures. This work reports the first successful use of hybrid toughening to increase both the quasi-static interlaminar fracture energy, G_{IC} , and the fatigue threshold strain-energy release-rate, G_{th} . Amine-cured epoxy glass-fibre composites were toughened using carboxyl-terminated butadiene-acrylonitrile (CTBN) which forms micron-sized rubber particles and 20 nm-diameter silica nanoparticles. The toughening mechanisms were identified as cavitation of rubber particles and debonding for the silica nanoparticles, followed by plastic void growth. The CTBN greatly increases G_{IC} , and the nanoparticles increase G_{th} . Combining both particles as a hybrid has a synergistic effect on the fatigue resistance. This demonstrates the effectiveness of hybrid toughening, enabling the design of optimised composites by combining micro- and nanoparticles.

Keywords:

A: Glass Fibres; A: Nanoparticles; B: Fatigue; B: Fracture

1. Introduction

Epoxy polymers can be used as adhesives, coatings or as the matrices of fibre-reinforced composite materials. They are highly crosslinked thermosetting polymers, and this structure results

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