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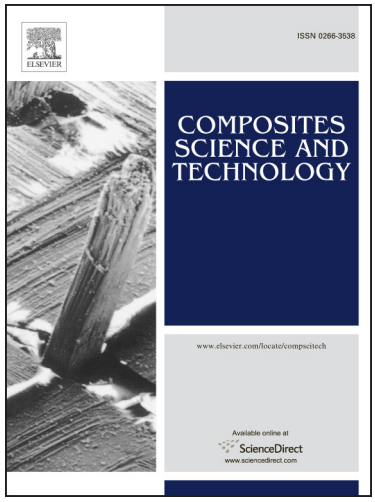

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Demonstration of pseudo-ductility in unidirectional discontinuous carbon fibre/epoxy prepreg composites

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Abstract

The inherent brittleness of continuous unidirectional fibre reinforced composites is a major drawback to their otherwise outstanding mechanical performance. This paper exploits composites with overlapped discontinuities at the ply level to create a significantly non-linear response, due to progressive interlaminar damage under tensile loading. Two distinct configurations were manufactured with the same carbon/epoxy system and tested under quasi-static tension, showing that varying the thickness and length of the overlapping ply blocks resulted in significantly different mechanical responses and failure modes. A previously developed generalised shear-lag model was successfully used to optimise the overlap configuration, and accurately predicted the response in both strength- and toughness-dominated cases. This work demonstrates that unidirectional composites with well-designed discontinuities at the ply level can provide a significantly non-linear response with clear warning before failure, while retaining similar stiffness and up to 50% of the strength of their continuous counterparts.

Keywords:
Discontinuous-ply composites; B. Non-linear behaviour; B. Delamination; C. Damage mechanics; C. Stress transfer;

1. Introduction

High performance carbon fibre composites offer exceptional stiffness- and strength-to-weight ratios, but suffer from sudden and brittle failure. There is usually very little or no warning before unstable failure and the residual load bearing capacity can be very poor. To ensure safe operation, a much greater safety margin is currently applied for composites than for more ductile materials such as metals, especially in critical applications. These design limitations can prevent engineers and operators from exploiting the outstanding stiffness and strength of carbon fibre composites, and render the materials unsuitable for applications in which loading conditions are not fully predictable and catastrophic failure cannot be tolerated. High performance composite materials that fail in a more ductile manner are therefore of exceptional interest and could potentially offer a substantial increase in the scope of applications, including transportation and civil engineering fields.

The study presented here aims at introducing pseudo-ductility into high performance fibre reinforced composites to make them suitable for new applications. One of the basic