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Experimental and numerical studies on the impact response of damage-tolerant hybrid unidirectional/woven carbon-fibre reinforced composite laminates

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ABSTRACT

A woven five-harness satin (5HS) weave with AS4 carbon fibres, and unidirectional high strength IMS60 carbon fibres were used to manufacture hybrid laminates, using resin infusion, to assess their performance in low velocity impact tests. Load/energy-time curves and load-displacement curves were extracted from the experimental data, and non-destructive C-scanning was performed on all pre- and post- impacted specimens to quantify the extent of damage incurred. A finite element-based computational damage model was developed to predict the material response of these hybrid unidirectional/woven laminates. The intralaminar damage model formulation, by necessity, consists of two sub-models, a unidirectional constitutive model and a woven constitutive model. The built-in surface-based cohesive behaviour in Abaqus/Explicit was used to define the interlaminar damage model for capturing delamination. The reliability of this model was validated using in-house experimental data obtained from standard drop-weight impact tests. The simulated reaction-force and absorbed energy showed excellent agreement with experiment results. The post-impact delamination and permanent indentation deformation were also accurately captured. The accuracy of the damage model facilitated a quantitative comparison between the performance of a hybrid unidirectional/woven (U/W) laminates and a pure unidirectional (PU) carbon-fibre reinforced composite laminates of equivalent lay-up. The hybrid laminates were shown to yield better impact resistance.

Key words: A: Laminates; B. Impact behaviour; C. Finite element analysis; D. Non-destructive testing;

1. Introduction

Carbon fibre reinforced polymers (CFRPs) have been widely adopted in modern high performance lightweight structures. The main advantages of composite materials include high specific strength, stiffness and good fatigue resistance [1–3].

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