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Experimental assessment of the mechanical behaviour of 3D woven composite T-joints

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Abstract

To understand the influence of the fibre architecture of 3D woven composite T-joints on mechanical performance, as well as the benefits that 3D woven T-joints can offer over the equivalent 2D laminates, experimental testing is performed on two types of 3D woven T-joint with only weave variation at the junction, and one type of 2D woven laminate T-joint. A quasi-static tensile pull-off loading is selected in this work as this out-of-plane load case is one of the typical loading conditions for such T-joint structures. The significant advantages of 3D woven composite T-joints in terms of ultimate strength and damage tolerance over the 2D alternative were identified in the testing. More importantly, this work showed that variation in the fibre architecture can considerably enhance properties such as delamination resistance and total energy absorption to failure, as well as increasing slightly the stiffness and initial failure load. This experimental assessment has demonstrated that using 3D woven reinforcements is an effective way to improve the load-bearing capability of composite T-joints over laminates, and also that this improvement could be optimised with regard to fibre architecture.

Keywords: A. 3-Dimensional reinforcement; B. Mechanical properties; B. Damage tolerance; D. Mechanical testing

1. Introduction

Composite T-joints are commonly used in aerostructures for joining of composites, with typical applications including spar-to-skin and stiffener-to-skin interfaces in wing structures, as well as bulkhead-to-skin interfaces in the fuselage [1, 2]. ‘T’ structures are also found as stiffeners to prevent skin buckling in aerostructures. The flange of the T-joint interacts with the skin, whilst the web provides an attachment to the substructure. For such applications, tensile (pull-out) and flexural loads are representative of typical in-service loading conditions [2], and hence the tensile and flexural tests on T-joints are reported in the literature. In addition, the T-shaped composite structures were extensively studied for the civil engineering sector, with an emphasis on the out-of-plane mechanical behaviour, e.g. pull-out or bending, of pultruded [3-6] and adhesively bonded structures [7]. As most of the composite T-joints are subjected to out-of-