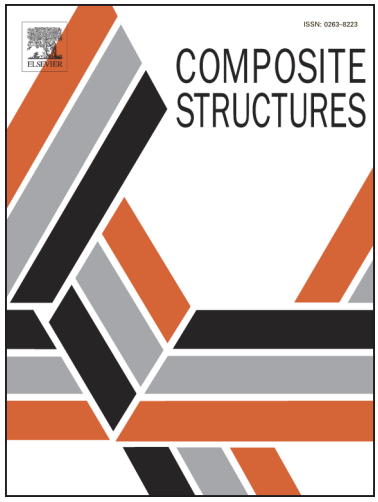

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Analytical modelling of the behaviour and scatter of the flexural modulus of randomly oriented carbon fibre strand thermoplastic composites

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ABSTRACT

Randomly oriented strand composites are promising materials for complex-shaped parts, especially in the aerospace and automotive industries. However, test data from small specimens tend to have a high level of scatter as these materials contain several centimetres of chopped carbon fibre strands. In this study, we investigated the mechanical properties of ultra-thin chopped carbon fibre tape reinforced thermoplastics (UT-CTT), which contain chopped thermoplastic thin-ply prepreg tapes produced using a paper-making technique. We propose a model for accurately evaluating the flexural modulus and its scatter, which was verified by comparison with experimental data. The predictions of the model showed excellent agreement with the experimental results. This method makes it possible to quantify the scatter of the flexural modulus and is useful for designing geometries of, not only standard test specimens, but also complex parts for actual applications.

Keywords: Carbon fibres; Discontinuous reinforcement; Statistical properties/methods; Mechanical testing

1. Introduction

Randomly oriented strand composites have high fibre content and are composed of chopped unidirectional strands. They are promising materials for complex-shaped parts, especially in the aerospace and automotive industries. This type of composites have been widely investigated, including experimental studies of the mechanical properties[1-8] and behaviour during moulding[9-11], as well as theoretical studies[12-16]. They have excellent formability for producing complex shapes and have already been applied to commercial products, such as the window frames of the Boeing 787 Dreamliner[17] and suspension control arms for the Lamborghini Sesto Elemento[18]. However, the mechanical properties of small specimens tend to show a high level of scatter[4,12,15] as these materials are composed of several centimetres of chopped fibre strands or tapes. This characteristic has made it difficult to accurately evaluate the behaviour of such materials and has prevented their wider application. Therefore, in order to reduce the scatter of the mechanical properties, thin-ply prepreg structures, which have been shown to effectively improve the mechanical properties of continuous fibre laminates[19-26], have been applied to randomly oriented strand composites[27,28]. In these studies, the authors focused on composites composed of carbon fibre (CF) and a thermoplastic matrix, i.e., ultra-thin chopped carbon fibre tape reinforced thermoplastics (UT-CTT).

The properties of UT-CTT have smaller scatter than those of conventional discontinuous fibre composites with chopped strands, but more scatter than those of continuous fibre laminate. Hence, in