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PII: S0263-8223(17)32758-7
DOI: https://doi.org/10.1016/j.compstruct.2018.05.078
Reference: COST 9717

To appear in: *Composite Structures*

Received Date: 30 August 2017
Revised Date: 10 May 2018
Accepted Date: 17 May 2018

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Abstract

This paper presents a multiscale modelling approach for thick composite structures containing internal defects and features. The proposed approach was developed using a surrogate model to represent the composite response on the meso-scale. A set of Representative Volume Element (RVE) models under periodic boundary conditions were used to sample the response at specified locations across the composite design space. As an example of its application, wrinkle defects of various severities were introduced to the RVE models to assess the defect contribution to the composite response. The homogenized responses from the meso-scale RVE models were then used as input to the surrogate model. To link the macro and meso scales, a set of 3D lamination parameters representing the composite layup were developed. A surrogate model using the 3D lamination parameters and the defect severity as input was built to link the macro-model to the meso-scale responses. The proposed multi-scale approach was verified against a set of high fidelity models with different levels of wrinkle defect severity. Good agreement was found between the new multi-scale approach and the more computationally expensive high-fidelity models.

1. Introduction

A main advantage of laminated fibre reinforced composite materials for structural applications comes from the ability to select the fibre orientation on a layer by layer basis, which leads to highly optimisable configurations. By carefully selecting the orientations, the stress and load paths within a structure can be tailored to achieve the desired performance [1, 2]. Additionally, enhanced damage tolerance can be built into the structure. Selected damage modes can be suppressed for the benefit of more favourable ones [3, 4]. However, this flexibility comes at the cost of a considerably more complex internal material architecture. The external geometric features of the structures such as curves, tapers, holes, and notches lead to a more complex internal architecture. For example, the presence of a feature such as ply drops to achieve a