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Nanomechanical characterisation of unidirectional fibre-reinforced composites at the fibre-matrix level

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The use of bottom-up multiscale methods has become the privileged approach to predict the deformation and failure of fibre-reinforced polymer composites. The development of accurate computational multi-scale models relies on the proper description of the individual components of the composite ply. The determination of the local properties of these constituents is challenging, dependent on the specific local curing conditions and generation of heterogeneities, and accurate data are scarce for the interfaces and interphases [1]. The matrix is usually described based on continuum models, yet this may lead to inaccurate prediction of the local strain field around fibres. These challenges limit the accuracy of composite model predictions, even for unidirectional (UD) composites loaded in transverse compression, where the macroscopic deformation response is dictated by the matrix [2]. In this study, we propose a combined experimental and numerical approach to characterise the constituents of a carbon fibre-reinforced UD composite. The measurement and prediction of the matrix response at the fibre/matrix level is of particular interest, as matrix size effects may exist at this scale. Nanoindentation is used to determine the properties of the matrix in confined volumes in-between fibres. Care is taking to deconvolute artefacts resulting from the test procedure and the data treatment on possible size effects. Transverse compression tests on UD specimens are conducted inside a scanning electron microscope (SEM) allowing the use of micro digital image correlation (DIC). The objective is to quantify the local strain field with an accuracy as small as a few tens of nano-metres. The DIC strain maps are confronted with FEA results using a model enriched by the nanoindentation measurements.

REFERENCES

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