STOCHASTIC COMPRESSIVE FAILURE SURFACE MODELLING FOR THE UNIDIRECTIONAL FIBRE REINFORCED COMPOSITES UNDER PLAINSTRESS

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Compressive failure mechanisms of unidirectional fibre composites have been studied extensively over the past decades. Under compression, industrially used composites with ~60% volume fraction typically fail with the phenomenon of plastic microbuckling also known as kinking. This failure mode is predominantly governed by fibre misalignment and matrix shear strength. Analytical and finite element models to predict kinking failure typically consider an idealized form of fibre misalignment in a localised region, e.g. [1]. However, measurements have shown that fibre misalignment of composite materials have a characteristic and inhomogeneous distribution over the whole volume with a Gaussian distribution, with material specific correlation lengths. In the past, little effort has been made to characterize material constituents' distribution of realistic specimens, e.g. [2].

In this contribution, a finite element modelling framework to capture the distribution of in-plane compressive failure strengths of unidirectional fibre reinforced composites resulting from the characteristic spatial distribution of fibre misalignments. The misalignment is characterized using a spectral density function of in-plane spatially varying misalignment angle distribution following the approach used by Liu et. al. [2]. Special consideration is given to size of misalignment defects and how such regions interact with each other and with boundaries. A homogenized anisotropic material model is used to represent the specimen accounting for matrix plasticity in shear. Computational efficiency and simplicity of this type of modelling approach allows for parametric studies.

Results of a specimen with idealized form of waviness with this approach are compared to a well-known analytical model [3]. Probability density functions (pdf) of failure loads of the composite are calculated using Monte Carlo simulations under different loading conditions. By using different combinations of load cases for each realization of spatially varying fibre misalignment, in-plane probabilistic failure surfaces of the composites are generated.

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