An experimental and numerical study on fatigue damage development in laminates containing embedded wrinkle defects

Supratik Mukhopadhyay, Oliver J. Nixon-Pearson, Stephen R. Hallett

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Supratik Mukhopadhyay*, Oliver J. Nixon-Pearson, Stephen R. Hallett

University of Bristol, Advanced Composites Centre for Innovation and Science, Queens Building, Bristol BS8 1TR, United Kingdom

*Corresponding author. Email: s.mukhopadhyay@bristol.ac.uk Tel: +44(0)1173315506

Abstract

Out-of-plane fibre waviness or 'wrinkle' defects significantly reduce the strength of laminated composites under quasi-static tension loads. Under tension-tension cyclic loading, the peak load amplitude remains lower than the wrinkled laminate quasi-static strength. Small delaminations can however still initiate early during the load history and grow steadily with increasing numbers of cycles until becoming critical, leading to ultimate structural failure. This paper focusses on the application of a novel 3D finite element modelling framework to predict fatigue delamination initiation and growth from wrinkle defects. An experimental programme was conducted alongside the modelling, for validation purposes. Carbon fibre/epoxy laminates with a quasi-isotropic layup containing artificially induced wrinkles were tested at various load severities (percentage of quasi-static failure load), until failure (defined percentage loss of the initial undamaged stiffness). Failure progression was closely monitored throughout the test. A detailed comparison between the novel finite element analyses and experiments was undertaken, and it was shown that the delamination locations, extent and cycles to failure could be very accurately predicted.

Keywords: Composites, Defects, Fatigue crack growth, Finite elements