

## Accepted Manuscript

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PII: S0142-1123(17)30400-0  
DOI: <https://doi.org/10.1016/j.ijfatigue.2017.10.008>  
Reference: JIJF 4482

To appear in: *International Journal of Fatigue*

Received Date: 7 August 2017  
Revised Date: 7 October 2017  
Accepted Date: 9 October 2017

Please cite this article as: Mukhopadhyay, S., Nixon-Pearson, O.J., Hallett, S.R., An experimental and numerical study on fatigue damage development in laminates containing embedded wrinkle defects, *International Journal of Fatigue* (2017), doi: <https://doi.org/10.1016/j.ijfatigue.2017.10.008>

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

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**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

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