

Influence of stacking sequence on the open-hole shear strength of composite laminates

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The failure behaviour of fibre-reinforced polymer (FRP) composite structures depends not only on the properties of the constituent fibre and matrix materials, but also on the lay-up, stress-state, and the size and configuration of structural features. The open-hole tensile (OHT) test, which is low-cost and simple to conduct, has been used for the extensive study of lay-up and size effects, as well as for the validation of ‘virtual’ testing techniques for composite materials [1]. Despite this, the lack of research that investigates lay-up and size effects of composites subjected to more complex loading, necessitating specialised loading rigs and advanced experimental techniques, means that their failure is poorly understood and that predictive tools are not fully validated. Therefore, extending the work on OHT experiments, the influence of stacking sequence on the open-hole shear (OHS) strength of quasi-isotropic unidirectional (UD) carbon fibre reinforced laminates is investigated in this study. The modified Arcan fixture (MAF) [2] is used to induce shear in composite open-hole specimens with two different lay-ups as shown in Fig. 1, while stereo digital image correlation (DIC) is used to observe the damage behaviour (see Fig. 2). A significant difference in open-hole shear strength has been found that is attributed to two distinctly different failure modes observed in the DIC maps. Finite-element (FE) models have been used to investigate the ply-by-ply stress/strain states to further understand the underlying failure mechanisms. A state-of-the-art FE-based damage model [3] developed for the virtual testing of composite aero-structures has then been assessed against the experimental data. The experimental and numerical results can be used to inform laminate design and to improve and validate modelling frameworks for composite materials and structures.

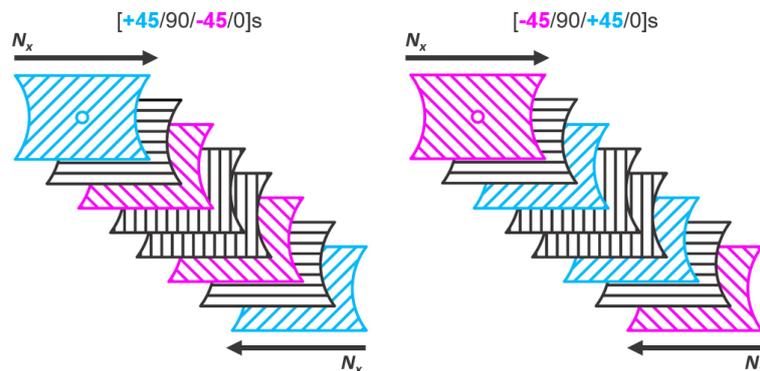


Fig. 1: The two laminate lay-ups tested in shear on the modified Arcan fixture (MAF).

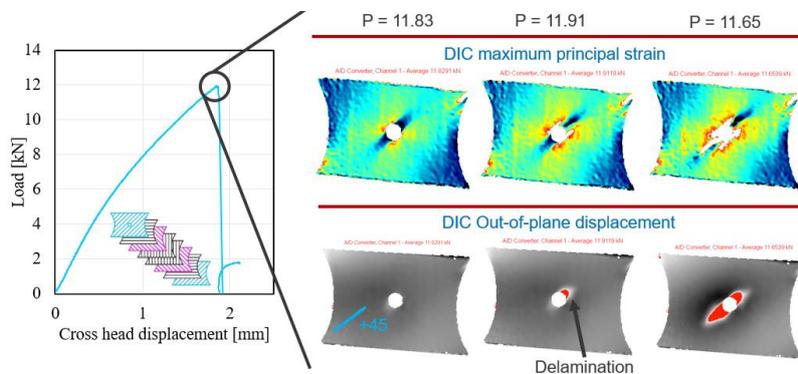


Fig. 2: Example experimental result.

References

- [1] S.R. Hallett et al., The open hole tensile test: a challenge for virtual testing, *Int J Fract* Vol. 158 (2009), p 169-181.
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