Accepted Manuscript

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PII: S0263-8223(16)00034-9
DOI: http://dx.doi.org/10.1016/j.compstruct.2016.01.021
Reference: COST 7126

To appear in: *Composite Structures*

Please cite this article as: Saleh, M.N., Lubineau, G., Potluri, P., Withers, P., Soutis, C., Micro-mechanics based damage mechanics for 3D Orthogonal Woven Composites: Experiment and Numerical Modelling, *Composite Structures* (2016), doi: http://dx.doi.org/10.1016/j.compstruct.2016.01.021

Micro-mechanics based damage mechanics for 3D Orthogonal Woven Composites: Experiment and Numerical Modelling

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Abstract

Damage initiation and evolution of three-dimensional(3D) orthogonal woven carbon fibre composite (3DOWC) is investigated experimentally and numerically. Meso-scale homogenisation of the representative volume element (RVE) is utilised to predict the elastic properties, simulate damage initiation and evolution when loaded in tension. The effect of intra-yarnstransverse cracking and shear diffused damage on the in-plane transverse modulus and shear modulus is investigated while one failure criterion is introduced to simulate the matrix damage. The proposed model is based on two major assumptions. First, the effect of the binder yarns, on the in-plane properties, is neglected, so the 3DOWC unit cell can be approximated as a ($0^o/90^o$) cross-ply laminate. Second, a micro-mechanics based damage approach is used at the meso-scale, so damage indicators can be correlated, explicitly, to the density of cracks within the material. Results from the simulated RVE are validated against experimental results along the warp (0^o direction) and weft (90^odirection). This approach paves the road for more predictive models as damage evolution laws are obtained from micro mechanical considerations and rely on few well-defined material parameters. This largely differs from classical damage mechanics approaches in which the evolution law is obtained by retrofitting experimental observations.

Keywords:Carbon fibre; 3-Dimensional reinforcement; Homogenisation; Micro-mechanics