A mesoscopic model to predict ply-failure mechanisms in fibre-reinforced composites

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Mesoscopic constitutive models employed to predict the mechanical response of fibre-reinforced composites at the level of the unidirectional ply are typically formulated under the small strain assumption. However, this assumption may become inadequate for situations where large deformations are observed in the material when it is loaded up to failure. It may be the case of load cases leading to a matrix governed response, especially in the case of fibre-reinforced thermoplastics, which have the potential to become important structural materials in aeronautical applications due to their recyclability. The visco-elastic–visco-plastic response of fibre-reinforced polymers has been addressed by the authors in [1].

However, it has been recently demonstrated in [2] that finite strains must also be appropriately accounted for in damage models to accurately predict the progressive failure behaviour of composites. Therefore, an approach based on the finite strain version of the smeared crack model introduced in [3] is discussed. The onset of transverse matrix cracking is evaluated by an invariant-based criterion and its evolution is described through an homogenisation-based kinematic description of the cohesive crack. An extrinsic mixed mode cohesive law is employed to deal with non-monotonic load-unload-reload conditions. The local cohesive equilibrium problem is formulated in the reference configuration, enabling a natural inclusion of the crack-plane re-orientation. The smeared crack model is combined with a continuum damage model formulated in terms of the Green-Lagrange strain tensor, to include longitudinal failure mechanisms. The implementation of this approach for finite element solution with Abaqus/Explicit is addressed. Some numerical examples are also presented to illustrate the applicability of this model in the prediction of experimentally observed phenomena.

References

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