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COMPUTATIONAL MODELLING OF FAILURE, DELAMINATION AND FATIGUE IN COMPOSITE MATERIALS AND STRUCTURES

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ABSTRACT

The increasing use of composite materials in lightweight and high-performance structures has intensified the need for reliable numerical tools for the prediction of failure and long-term durability. Due to their anisotropic and heterogeneous nature, damage and failure mechanisms in composites involve complex interactions between matrix cracking, fibre degradation, interface debonding, and delamination across multiple scales, under both monotonic and cyclic loading conditions.

The predictive simulation of these mechanisms remains particularly challenging due to the strong coupling between intralaminar and interlaminar damage processes, material anisotropy, path dependency, and the interaction between multiple length scales, ranging from constituent-level degradation to the structural response. Particular interest is devoted to models capable of capturing the interaction between different failure mechanisms under complex loading paths, including multiaxial stress states, variable amplitude loading, and coupled thermo-mechanical effects.

This invited session aims to gather recent advances in the computational modelling of failure, delamination, and fatigue in composite materials and structures. Contributions on constitutive modelling, multiscale approaches, interlaminar damage and delamination, fatigue damage evolution, life prediction methodologies, numerical implementation, and experimental validation are particularly welcome.

Special attention will be given to advanced numerical methodologies, including finite element formulations, cohesive zone and phase-field approaches, multiscale homogenization techniques, reduced-order models, and data-driven or hybrid computational strategies. Contributions addressing virtual testing, model calibration and validation, uncertainty-aware life prediction methodologies, as well as the influence of manufacturing-induced defects, porosity, residual stresses, and geometrical imperfections, are also encouraged.

Applications to engineering structures in aerospace, automotive, civil, and energy sectors, including design, durability assessment, and certification-oriented virtual simulations, are particularly welcome.