A COMPUTATIONAL ANALYSIS OF THE INFLUENCE OF MICRO-SCALE MATERIAL IMPERFECTIONS ON IMPACT PERFORMANCE OF FRP COMPOSITES

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Uncertainties such as material imperfections in fibre-reinforced polymer (FRP) composites are inevitable and can occur on a constituent level (micro-scale), ply level (meso-scale) and component level (macro-scale) [1]. Many investigations analyse the effect of macro- and meso-scale uncertainties on impact damage in FRP composites. However, it is uncertain to what extent micro-scale imperfections influence the impact performance.

One critical damage scenario in aviation is the low velocity impact (LVI). This damage type can cause a barely visible impact damage (BVID) to a structure and might remain undetected. Thus, the BVID can grow during service life resulting in a reduction of residual strength and possibly ultimately structural failure. It emerges that the influence of imperfections must be considered when calculating impact events. Further, a recent study showed the necessity of an investigation of scatter effects after LVI that might be caused by micro-scale imperfections [2].

In general, the uncertainties are considered by conventional knockdown factors during damage analysis accounting for the worst-case scenario. This conventional, deterministic approach is simple and reasonable but not the most suitable since it may lead to oversizing and increased costs. In order to enable more accurate dimensioning, a more accurate damage analysis and a deeper understanding of the effect of imperfections on the impact performance is required. The present work investigates the effect of micro-scale material imperfections on the impact damage. Since there is a variety of uncertainties arising from the constituent level, only one type of the identified, potentially significant imperfections was further investigated. Stochastic material properties representing the imperfection were identified and a FEM model was utilized comprising a continuum material model for intraply damage and cohesive surfaces for delamination. Finally, delamination and fibre breakage behavior were analysed and compared with a reference model. The results show a significant influence of the stochastic scatter of the appropriate material parameters on delamination as well as fibre breakage behavior.

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