Modelling of self-sensing hybrid composites for detection of barely visible impact damage

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Abstract. Barely visible impact damage (BVID) may decrease by up to 60% compressive strength of laminates compared with an undamaged laminate. Hence, BVID detection ant its extent is an essential yet expensive task in the inspection of laminates. In this study, a finite element (FE) model is developed to simulate a novel hybrid composite with BVID self-sensing ability. The hybrid composite is made of a quasi-isotropic T800 carbon/MTM49-3 epoxy laminate with a surface integrated sensing layer consisting of single plies of unidirectional ultra-high modulus carbon (YS-90)/epoxy and S-glass/epoxy material. The sensing layer experiences visually detectable damage earlier or at the same time as BVID. The induced damage in the sensor is ultra-high modulus carbon fracture followed by incremental crack growth at the carbon/glass interface and splits in the glass layer along the fibres. Modified cohesive elements with a user-defined subroutine are used in LS-Dyna software to simulate the damage sequence. The developed FE model is validated experimentally, and the results show direct relationships between visible damage in the sensing layer and internal hidden damage observed by C scan and simulated by the FE model. This offers self-sensing composites with cost effective and more durable BVID detection capacity than the current technologies.

Keywords: Hybrid laminated composites, Barely visible impact damage, Low velocity impact, Sensing, Finite element.