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Mesoscale and macroscale modelling of the quasi-static crushing behaviour of 2D woven CFRP Formula 1 crash structures

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The commercial design tools currently available to F1 teams are not suitable for performing accurate simulations of structural composite crushing. Thus, extensive experimentation is required during the component development phase, making the process prohibitively expensive, unless significant limits are placed on the design space that can be explored. Through the use of improved numerical predictive tools, namely Finite Element (FE) composite damage models, engineers will be better equipped to accurately predict the crushing behaviour of such structures, allowing them to better optimise the final designs within a shorter timeframe and in a cost-efficient manner.

This work presents two numerical simulations of the quasi-static crushing behaviour of a Formula 1 Side Impact Structure (SIS), performed with mesoscale and macroscale composite damage models. Both simulations were performed using an explicit formulation within the software package Abaqus. The mesoscale simulation included ply-level modelling, with the use of 3-Dimensional (3D) reduced integration brick elements (C3D8R). An intralaminar damage model, based on the initial work of Faggiani and Falzon [1], and later adapted to 2D woven materials, was used to model damage initiation and propagation within these 3D ply elements. The interlaminar region between plies was modelled using the Abaqus in-built cohesive surface behaviour. The macroscale simulation was performed using 2-Dimensional (2D) reduced integration shell elements (S4R), together with an in-built Abaqus composite damage model, and the CZone plug-in within Abaqus.

This work evaluates the potential for using both mesoscale and macroscale damage models to simulate the progressive crushing of real industry-level components. The numerical results are assessed on the quantitative and qualitative accuracy of the simulation when compared to experiments.

[1] Faggiani A, Falzon BG. (2010) *Compos Part A Appl Sci Manuf*. **41**:737–49.