Low-velocity impact simulation of a woven composite from a bottom-up multiscale modelling strategy

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Abstract

The determination of ply properties of fibre-reinforced polymers (FRPs) is necessary to succeed in component design. However, traditional experimental characterisation methodology requires significant resource and time investments. As an alternative, the use of a bottom-up multiscale modelling strategy is proposed[123] (see Figure 1). In this work, this alternative is utilized to determine the mechanical behaviour of a woven fabric composite made of glass fibre and polypropylene. The main goal is to simulate the low-velocity impact response of the woven composite by using such properties.

Until the achievement of the objective, the work goes through three distinct phases. The first one consists in a coupled numerical/experimental study within the framework of micromechanics. This is intended to find the properties of yarn that allow the formulation of a constituent model for its behaviour. The second is based on predicting composite layer properties using a ply unit cell model. For this purpose, the unit cell model was subjected to uniaxial tensile, compressive and shears loads as well as to combined loads that allow failure envelopes to be deduced (see Figure 2). Additionally, double cantilever bean test and compact tension test were performed in order to obtain interlaminar properties and tensile fracture energy, respectively. The third and final phase is the simulation of the low-velocity impact test itself, which constitutes a validation test of the proposed methodology (see Figure 3).

Keywords: Computational micromechanics and mesomechanics, multiscale modelling

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Figure 1. Illustration representing bottom-up multiscale modeling strategy.

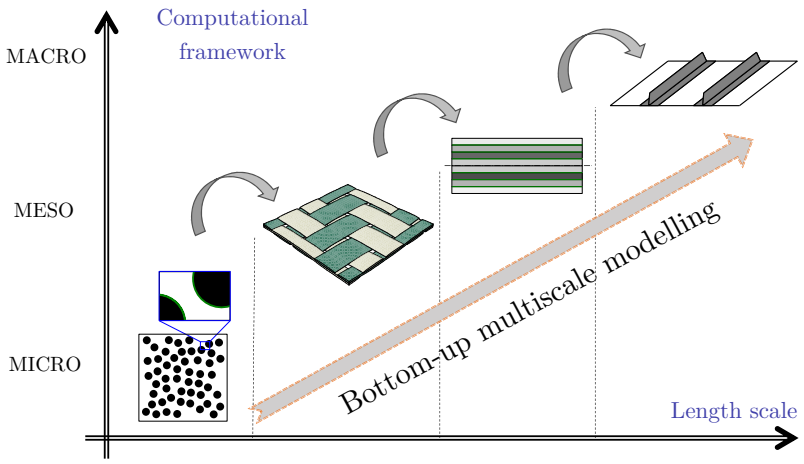


Figure 2. Failure envelopes of the composite ply.

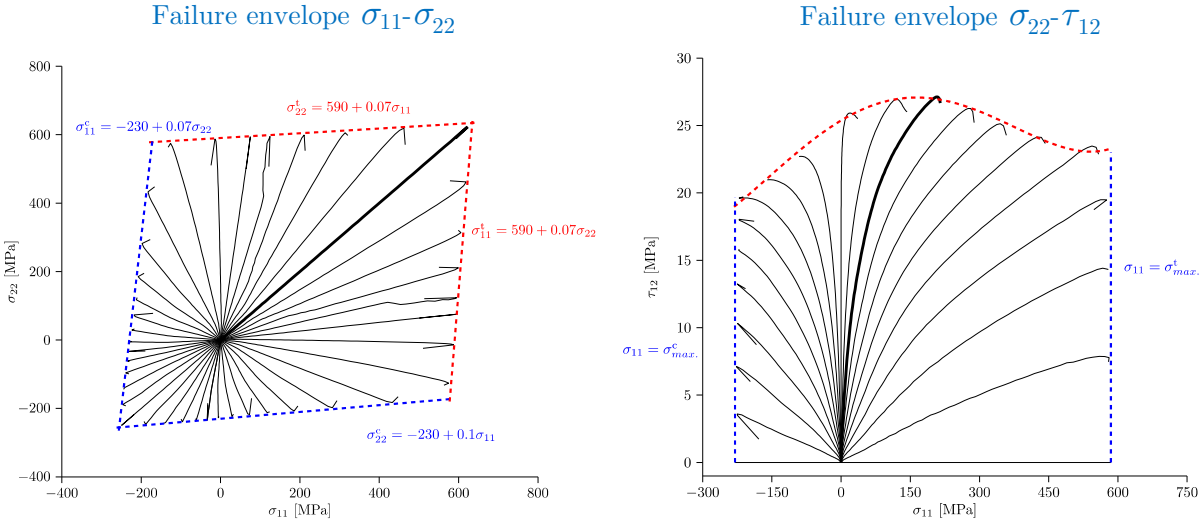
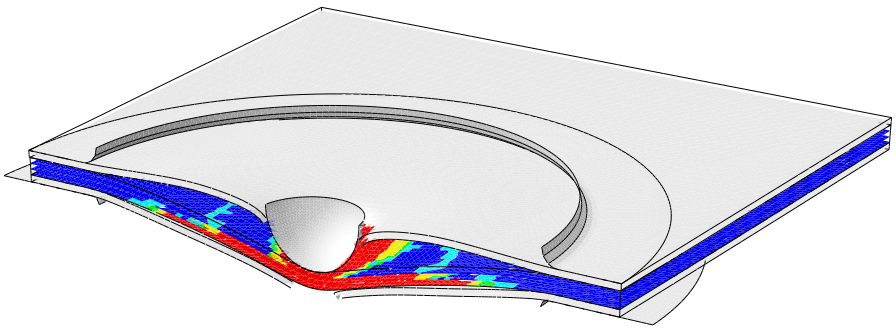


Figure 3. Example of low-velocity impact simulation.



1. Llorca, J. et al. Multiscale modeling of composite materials: A roadmap towards virtual testing. Adv. Mater. 23, 5130–5147 (2011).
2. Lopes, C. S. et al. Multiscale virtual testing: the roadmap to efficient design of composites for damage resistance and tolerance. CEAS Aeronaut. J. 7, 607–619 (2016).
3. Lopes, C. S., Sádaba, S., Naya, F. & González, C. Multiscale Simulation Strategy for Low-Velocity Impact on FRP. in American Society for Composites - 29th Technical Conference, ASC 2014 (2014).