A micro-model of the intra-laminar fracture in fiber-reinforced composites based on a discontinuous Galerkin/extrinsic cohesive law method

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The hybrid discontinuous Galerkin (DG)/extrinsic cohesive law (ECL) method was recently proposed [1] to circumvent the drawbacks of the cohesive element methods. With the DG/ECL method, prior to fracture, the flux and stabilization terms arising from the DG formulation at interelement boundaries are enforced *via* interface elements in a way that guarantees consistency and stability, contrarily to traditional extrinsic cohesive zone methods. At the onset of fracture, the traction–separation law (TSL) governing the fracture process becomes operative without the need to modify the mesh topology since the cohesive elements required to integrate the TSL are already present. This DG/ECL method has been shown to be an efficient numerical framework that can easily be implement in parallel with excellent scalability properties to model fragmentation, dynamic crack propagation in brittle and small-scale yielding materials, both for 3D problems and for thin structures [1, 2].

In this work, following the developments in [3], the DG/ECL method is extended to the study of composite materials failures at the micro-scale. The method is applied to study the transverse traction of composite materials in characteristic micro-volumes of different sizes. The method captures the debonding process, assimilated to a damaging process before the strain softening onset. It is shown that the density of dissipated energy resulting from the damage (debonding) remains the same for the different studied cell sizes. During the strain softening phase, a micro-crack initiates and propagates, in agreement with experimental observations. After strain softening onset, the extracted macroscale cohesive law, obtained by the method proposed in [4], is ultimately shown to converge for the different cell sizes. The predicted behaviors are then compared to experimental results obtained from laminate tests, and are found to be in good agreement.

References

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