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NUMERICAL CALIBRATION OF THE INTERFACE PARAMETERS TO MODEL THE DELAMINATION OF COMPOSITE LAMINATES

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Delamination is one of the most treacherous failure modes for composite laminates. This motivates the huge number of studies devoted to this problem over the last decades [1].

In previous works [2–4], we have shown how the delamination of composite laminates can be effectively modelled by means of 'enhanced' beam-theory models, where the delaminated laminate is represented as an assembly of sublaminates, modelled as Timoshenko beams, connected by elastic–brittle interfaces. The resulting analytical problem can be solved determining explicit expressions for the interfacial stresses, internal forces and displacements. Consequently, the compliance, the energy release rate and the mode-mixity angle can be directly evaluated.

Actually, a crucial issue for the effectiveness of the abovementioned models is the determination of the interface constitutive law. In particular, the elastic constants of the distributed interfacial springs, k_x and k_z, have to be evaluated. These constants should be assigned in such a way as to account for the localised deformation occurring at the crack-tip, which is neglected by the 'simple' (*i.e.* without deformable interfaces) beam-theory models. A commonly adopted choice is to relate the interface parameters to the elastic moduli of the laminate in the out-of-plane direction, by setting $k_x = G_{zx} / t_x$ and $k_z = E_z / t_z$, where t_x and t_z are characteristic lengths determined according to some empirical consideration. Although such rough estimates have proven to be effective in many cases, a more in-depth investigation of this aspect seems necessary.

In this work, we show how the interface parameters can be determined accurately enough for practical purposes through a numerical calibration strategy, where the analytical predictions of the enhanced beam-theory models are matched with the numerical results of finite element models based on plane elasticity theory. In particular, we have developed a finite element model of a symmetrically delaminated specimen and performed two analyses corresponding to pure mode I (DCB) and II (ENF) fracture tests. Then, the elastic constants of the normal and tangential interfacial springs, k_x and k_z, have been determined, respectively, by matching the compliance obtained from the abovementioned numerical analyses with that stemming from analytical models. The obtained values can then be used to model mixed-mode fracture cases, such as the asymmetric double cantilever beam (ADCB) and mixed-mode bending (MMB) tests. The effectiveness of the proposed method is investigated by examining a wide spectrum of cases where the relevant parameters, such as the delamination length, thicknesses and mechanical properties of the sublaminates, are suitably varied.

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