A thermodynamically consistent cohesive damage model for the simulation of mixed-mode delamination

Federica Confalonieri* and Umberto Perego†

* Department of Civil and Environmental Engineering
Politecnico di Milano
Piazza Leonardo da Vinci, 32, Milano, Italy
e-mail: federica.confalonieri@polimi.it, umberto.perego@polimi.it

ABSTRACT

A new cohesive law for mixed mode delamination, based on a thermodynamic formulation with isotropic damage and internal friction, is presented in this work. The key feature of the model is a damage activation surface in terms of dimensionless cohesive tractions, accounting for three damage modes, namely one opening and two shear-dominated modes. As shown in figure 1, the activation surface is the result of the composition of three planes, whose outgoing normals define the three modes. The domain is described by means of a parameter of internal friction (α in the figure), representing the angle of inclination of the two shear-dominated modes. The introduction of this activation domain allows for an accurate modelling of the interaction between normal and tangential behaviour, even in the case of varying mode ratios. The overall strain energy release rate can be decomposed into the three contributions corresponding to each damage mode by projecting the cohesive tractions onto the three normals. The thermodynamic consistency of the model is guaranteed for any loading path. The input parameters required to completely define the model are the internal friction α, the fracture energies and the maximum normal and shear tractions in pure Mode I and Mode II. These parameters can be identified on pure Mode I and Mode II delamination tests and on mixed-mode tests, such as the Mixed-Mode Bending (MMB) test, providing the mixed-mode fracture energy for varying mode ratio. The model is able to reproduce the typical growth of the delamination fracture energy in passing from pure mode I to pure mode II, as evidenced in many experimental tests performed with the MMB setup ([1], [2], [3]). The proposed cohesive model has been validated on several benchmark tests available in the literature.

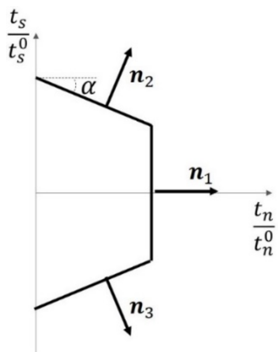

Figure 1. Three-surfaces activation domain

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