Università degli Studi di Pavia
Computational Mechanics & Advanced Materials Group - DICAr

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Regione Lombardia

SEMINAR

Explicit Simulation of Blade Cutting and Delamination

The topic of this seminar is a finite element computational tool for the simulation of blade cutting, fracture and delamination phenomena in thin-walled structures.

The first part of the talk will focus on the description of an ad-hoc computational strategy developed for the simulation of crack propagation induced by blade cutting in thin-walled structures. In addressing this problem, three distinct length scales, namely the shell thickness, the cohesive process zone length and the blade radius of curvature, have to be resolved. The thin-walled structure is discretized with eight-nodes solid shell elements, which allow for an easily implementation of fully three-dimensional constitutive behaviour and for the cohesive description of fracture phenomena. Moreover, the presence of different layers can be easily reproduced by stacking up one or more solid shell elements per layer through the thickness. Because of the high non linearity of the problem, a conditionally stable, explicit integration scheme is adopted. An ad-hoc selective mass scaling technique is introduced to reduce the computational burden due to the small element thickness that leads to a very small critical time step. Since the blade curvature radius turns out to be far smaller than the typical size of a computationally acceptable in-plane discretization of the process zone, standard cohesive elements fails in correctly reproduce the interaction of the cohesive zone with a sharp blade. Directional cohesive elements, i.e cohesive string elements able to detect contact with the blade, are, thus, introduced along separating element edges to properly simulate the blade cutting phenomenon, accounting for the interaction between the blade and the process zone in transmitting the cohesive forces between the two flanks of the crack.

In the second part of the seminar, an isotropic damage cohesive model specifically conceived for the numerical simulation of mixed-mode delamination problems will be described. Delamination, i.e. the decohesion between layers, is one of the most frequent failure modes in composite materials, often characterized by the concurrent presence of normal and shear inter-laminar stresses, leading to mixed-mode conditions with variable mode ratio. As shown by a number of experimental works on composite materials, the fracture energy significantly grows in passing from pure Mode I to pure Mode II, as a result of different micromechanical mechanisms involved in the delamination process. The proposed model, developed in a thermodynamically consistent framework, accounts for the interaction between normal and shear openings and is able to capture the non-monotonic increase of fracture energy for increasing mode ratio.

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November 28th, 4:00pm
DICAr MS1 Meeting Room
Via Ferrata, 3 – Pavia