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AN EFFICIENT APPROACH TO STUDY MULTI-LAYERED STRUCTURES WITH COHESIVE INTERFACES

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Delamination damage growth in multi-layered plate and shell structures loaded dynamically is conveniently studied using fracture mechanics principles and a discrete-layer approach, which describes the system as an assemblage of layers joined by cohesive interfaces (e.g. [1-3]). The interfaces define all actual and potential fracture surfaces in the system and cohesive traction laws are introduced, which relate the interfacial tractions to the relative displacements between the layers, in order to descriBe all different nonlinear mechanisms taking place at the interfaces, e.g. material rupture, cohesive/bridging mechanisms, elastic contact, ... This approach leads to accurate solutions of the problem but it is computationally very expensive since the number of unknowns of the problem depends on the kinematic description of each layer and on the number of layers chosen to discretize the system. If the First Order Shear Deformation theory is used to for the kinematic description of the layers in a plate or a shell, the number of displacement unknowns is 5×n (with n the number of layers).

A novel approach, based on a homogenization technique, has been recently proposed by the authors to study the dynamic response of multilayered plates and shells with cohesive interfaces [4,5]. The model extends to systems with generally nonlinear cohesive interfaces a theory which was originally formulated for systems with linearly elastic interfaces [6,7,8] (omissions in the original theories have also been corrected in [5]). As in a classical discrete-layer model, the system is decomposed into layers and cohesive interfaces. A two length-scales displacement field is then assumed, which is characterized by a global displacement (continuous and with continuous derivatives in the thickness) and local perturbations or enrichments (piece-wise linear with jumps at the interfaces). Through the a-priori imposition of interfacial continuity conditions, a homogenized displacement field is derived, which depends on the global displacement variables only. Hamilton principle of elastokinetics is then used to obtain the equilibrium equations. The equations depend on a reduced number of unknowns, independent of the number of layers used to discretize the system. In a plate or a cylindrical shell, for instance, the number of displacement unknowns is reduced from 5×n, as in a classical discrete layer model, to 6. The model has been validated with rigorous elasticity solutions in [2] for multi-layered plates with sliding interfaces deforming in cylindrical bending. Work in progress deals with the validation of the approach in the presence of mixedmode interfaces and for the evaluation of fracture parameters. The formulation of the model and applications to different problems will be presented at the meeting.

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