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Numerical simulation of damage in polymeric matrix composites

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ABSTRACT

The mechanical behavior until failure of polymer matrix composites is studied using computational micromechanics technics. The research is centered on the transverse behavior of long fiber reinforced composites considering two damage mechanisms: matrix failure and fiber-matrix interface decohesion.

Interface decohesion is simulated by cohesive finite elements and matrix damage using the plasticity model with porosity evolution proposed by Jeong [1,2]. The Jeong's model is a plasticity model that modifies the Druker Prager's yield function introducing a damage variable, the porosity, that evolves with the strain and stress field values. The failure behavior of most of the polymers used in composite materials can be simulated with this model varying the sensitivity of the matrix to the hydrostatic stresses, the porosity evolution and the matrix hardening/softening.

The model has been implemented using a visco-plastic formulation in order to avoid the localization of the damage in a band of one element of width (visco-plastic regularization [3]). The parameters of the visco-plastic model have been selected to obtain a macroscopic response very close to the rate-independent model but with damage concentrated in band independent of the mesh size, see figure 1.

The behavior of the materials is obtained by the finite element simulation of representative volumes of the transversal section of the composite. Different matrices have been used ranging from brittle to ductile behavior and different values of the strength of the interface between the matrix and the fibers has also been studied. The results obtained with the micromechanical simulations are compared with some macroscopic fail criterions as Tsai-Hill and Puck.

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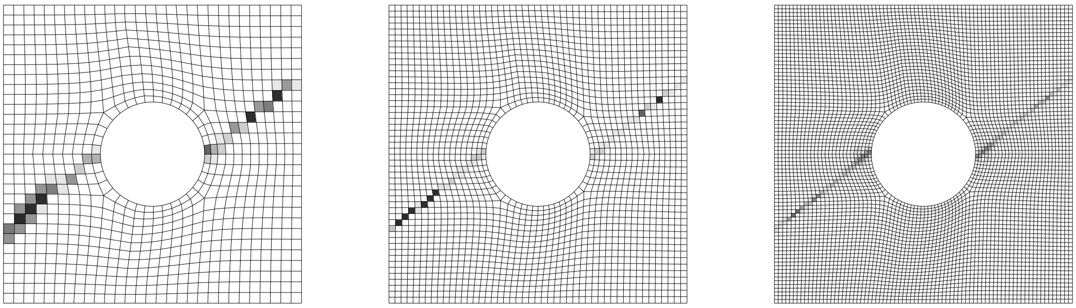
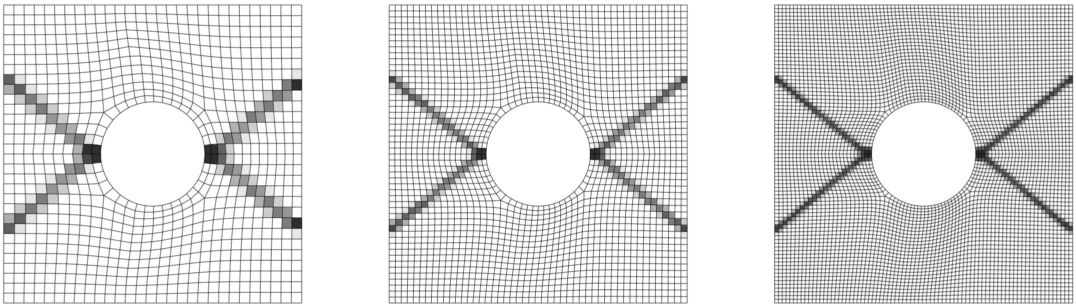


(a)



(b)

Figure 1: Unixial deformation of a panel with a hole in the middle (a) Damage localization in one element width band using a rate-independent formulation of the Jeong's model (b) Effect of a visco-plastic regularization: the width of the band becomes independent of the mesh size