Combining Damage and Fracture Mechanics for the identification of crack propagation parameters

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This presentation deals with accurate identifications of the crack tip position and fracture energy of cracked media. To model fracture or damage, a phase-field model was employed [6, 7] based on the variational formulation of Bourdin et al. [1]. The governing approach used herein was described in detail in Ref. [8], and the corresponding implementation was based on so-called pfm-cracks [4]. This framework allows for parallel computations and mesh refinement with both uniform and locally adapted meshes. Consequently, the phase-field internal length scale can be easily adapted.

A crack opening displacement-controlled virtual test on a decimetric beam representative of mortar was studied. The material had a non-negligible fracture process zone size (of the order of one centimeter). This means that the crack tip position cannot be precisely determined. In damage mechanics or regularized fracture using phase-field (or peridynamics) [2], the crack tip is usually approximated by a smoothed indicator variable. This is a major difference for this type of model compared to fracture mechanics solutions that explicitly deal with (discontinuous) cracks.

The main objective of this study was to combine phase-field with fracture mechanics models to extract the crack tip position from the simulations in addition to the fracture energy and process zone size. The analysis was inspired by the use of Williams' series [9] in integrated Digital Image Correlation [3] and elastoplastic simulations [5]. In the present case, instead of using experimentally measured displacement fields, they resulted from phase-field simulations to determine the amplitudes of each Williams' field via least squares minimization. The proposed approach accounted for various mesh refinements, as well as the analysis of the numerical and identification residuals.

The results allowed us to conclude about the dependence between the phase-field variable at the crack tip and the internal length at any loading step. This conclusion adds more knowledge and accuracy to usual criteria in damage mechanics that approximate the crack tip position for a fixed damage level.

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