Accepted Manuscript

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PII: S0045-7825(18)30137-3
DOI: https://doi.org/10.1016/j.cma.2018.03.012
Reference: CMA 11818

To appear in: *Comput. Methods Appl. Mech. Engrg.*

Received date : 31 October 2017
Revised date : 8 March 2018
Accepted date : 12 March 2018

Please cite this article as: J. Bleyer, R. Alessi, Phase-field modeling of anisotropic brittle fracture including several damage mechanisms, *Comput. Methods Appl. Mech. Engrg.* (2018), https://doi.org/10.1016/j.cma.2018.03.012

Phase-field modeling of anisotropic brittle fracture including several damage mechanisms

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Abstract

The present paper aims at modeling complex fracture phenomena where different damaging mechanisms are involved. For this purpose, the standard one-variable phase-field/gradient damage model, able to regularize Griffith's isotropic brittle fracture problem, is extended to describe different degradation mechanisms through several distinct damage variables. Associating with each damage variable a different dissipated fracture energy, the coupling between all mechanisms is achieved through the degradation of the elastic stiffness. The framework is very general and can be tailored to many situations where different fracture mechanisms are present as well as to model anisotropic fracture phenomena. In this first work, after a general presentation of the model, the attention is focused on a specific paradigmatic case, namely the brittle fracture problem of a 2D homogeneous orthotropic medium with two different damaging mechanisms with respect to the two orthogonal directions. Illustrative numerical applications consider propagation in mode I and II as well as kinking of cracks as a result of a transition between the two fracture mechanisms. It is shown that the proposed model and numerical implementation compares well with theoretical and experimental results, allowing to reproduce specific features of crack propagation in anisotropic materials whereas standard models using one damage variable seem unable to do so.

Keywords: complex fracture, phase-field, gradient damage, anisotropic fracture, brittle fracture, variational model

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