An experimental study of crack growth under compression using a Phase-field theory

P. Hesammokri*, H. Yu, P. Isaksson

Solid Mechanics, Dept of Materials Science and Engineering, Uppsala University, Sweden
parnian.hesammokri@angstrom.uu.se

Phase-field theories have gained a great deal of attention in recent years for their application to numerically modeling fracture. While phase-field theories have many advantages, one that stands out is that the crack mechanics are inherently derived from a minimization framework that couples strain and fracture energies. It is, however, necessary to decompose the strain energy density into tensile and compressive components in order to prevent interpenetration of crack surfaces and to select crack paths that are physically trustworthy. Spectral decompositions [1] and hydrostatic-deviatoric decompositions [2] are among the most popular methods of decomposing the strain energy density. Both of these decomposition techniques have a number of disadvantages, the most significant being that neither is able to adequately handle crack growth in compression [3]. There have been several attempts made to address this issue through the development of alternative decomposition schemes for the simulation of fracture under compression cf. [4,5]. There is, however, a drawback to these models, which is the fact that as a crack develops, stiffness may remain with a fully developed crack subjected to a shear load. Recently a model has been proposed to circumvent this problem by presenting a modified strain energy decomposition that is a combination of spectral and hydrostatic-deviatoric decompositions and is inspired by the classical Mohr-Coulomb fracture criterion [6]. In this study, this model is tested against a series of compressive tests in order to demonstrate its capability to predict the crack paths. The tests were conducted on specimens made of gypsum plaster which contained multiple embedded flaws and holes. The numerical results with a unique set of material parameters have been compared to experimental data both in terms of crack pattern and loading curve and they were in good agreement showing that the model is providing mechanistic insight into the fracture of brittle materials.

References

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