Simulation of Hertzian indentation fracture using a phase field approach

Michael Strobl*‡, Thomas Seelig‡

‡Institute of Mechanics, Karlsruhe Institute of Technology,
Kaiserstraße 12, 76131 Karlsruhe, Germany
michael.strobl@kit.edu, thomas.seelig@kit.edu

ABSTRACT

Phase field models of fracture have received a great deal of attention in recent years. The regularized description of cracks [1] renders Francfort and Marigo's variational model of brittle fracture easily available to compute complex crack patterns, including e.g. mesh-independent crack nucleation from geometrically induced stress concentrations.
The present contribution focuses on the phase field simulation of fracture caused by indentation loading. Fracture initiation from the defect-free surface of a brittle solid subjected to compressive loading by a hard indenter has already been described by H. Hertz more than a century ago. Its theoretical prediction, however, is still a challenging task due to the lack of appropriate criteria for crack formation in classical fracture mechanics. The issue of indentation fracture *initiation* can be solved by the concept of finite fracture mechanics which comprises strength and toughness as two independent material parameters [2]. Although not directly visible, both parameters are also present in phase field formulations of fracture.
In order to reproduce key features of indentation fracture such as crack initiation in absence of stress singularities [3] or the influence of Poisson's ratio on the subsequent evolution of cone cracks [4], extensive modifications of the phase field approach are required. These modifications comprise constitutive assumptions to prevent damage in compressed areas but also address the role of the regularization length. Its suitable choice becomes one of the major questions and turns out to be a controversial issue.
Numerical results are discussed for different indentation loading conditions and the method's capabilities are illustrated by comparison with other numerical as well as experimental results.

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