Master Thesis Project at the Division of Material and Computational Mechanics

Phase-field modeling of fatigue crack propagation

Background

Modeling of fracture in solids using the finite element method aims at simulating the overall mechanical response of a body while predicting the development of the discrete fracture, i.e. crack, during loading. The critical issues related to such simulations are (i) the kinematic description and (ii) the criteria for advancement of the crack. In full-fledged 3D simulations (where the fracture is represented by surfaces and the crack-tip is a line segment) and/or during complex loading and material heterogeneities, simulation of such crack-propagation becomes extremely difficult.

One way of tackling such difficulties is the use of so-called phase-field models, where the crack is modelled in a smeared sense in terms of a field variable (the phase-field) ranging continuously from 0 (full material integrity) to 1 (fracture). This approach alleviates the need to model the discontinuity explicitly in the numerical analysis. However, it requires a continuum model for the local evolution of the phase-field variable which must be calibrated to fit experimental results.

The application to phase-field fracture to static and dynamic fracture is a research topic attracting great interest in the engineering community. Proposed models are able to accurately predict crack-patterns as well as the overall mechanical response. However, it has so far been restricted to monotonic static loading or high-velocity dynamic fracture.

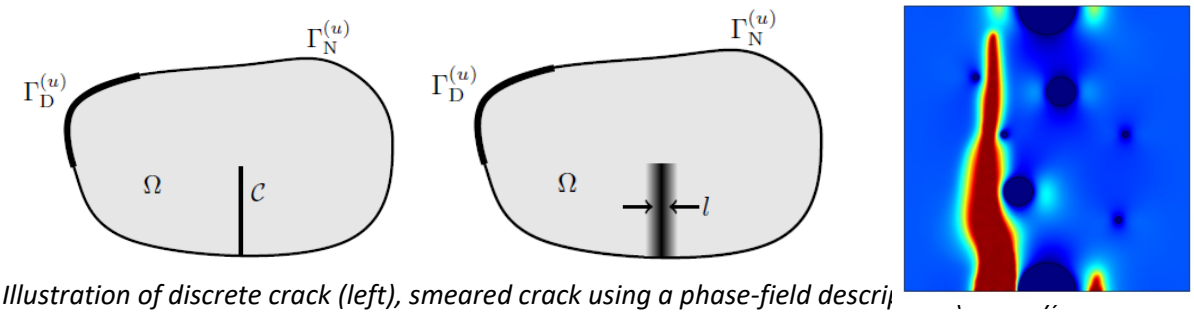

Figure: *Illustration of discrete crack (left), smeared crack using a phase-field descri ample numerical simulation of crack-propagation (under monotonic loading) in a heterogeneous medium (right). (Bharali et al. 2020)*

Purpose and project description

This master thesis aims at developing and evaluating phase-field models for fatigue crack-growth. In addition to a literature survey, the project will mainly consist of (i) development and calibration of constitutive models for phase field evolution, and (ii) implementation of a (two-dimensional) finite element code with for elasticity coupled to phase-field damage. The results from simulation will be compared to fatigue crack-growth experiments in literature. The numerical implementation can be carried out in, e.g., Matlab or Python, depending on the experience of the candidate(s).

Student background

This project is suitable for one or two students who are interested in computational mechanics (finite element analysis) and fatigue and fracture modeling. Students with strong interest and good experiences in programming are encouraged to apply.

Contact information

Fredrik Larsson, Chalmers/Industrial and Materials Science, fredrik.larsson@chalmers.se (Examiner)
Ralf Jänicke, TU Braunschweig, r.janicke@tu-braunschweig.de
Anders Ekberg, Chalmers/Mechanics and Maritime Sciences, anders.ekberg@chalmers.se