Modelling of Brittle Fracture of Concrete Material by the Phase-field Approach and Representative Crack Elements (RCE)

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ABSTRACT

The brittle form of fracture for solids and structures is a challenging failure phenomenon to predict. This mechanism, which is caused by breakage of the material, occurs without apparent deformations before the crack is formed. Due to separation of the body during crack phenomena, the load-carrying capacity of the material drops significantly. Stress concentrations, displacement field discontinuities and crack-growth instability are the factors, which make the fracture of brittle material not easy to predict accurately. Furthermore, change of mode and mixed fracture mode during several load applications induce more complexity to predict the crack evolution. Strobl and Seelig [1] and Steinke and Kaliske [2] have shown, that the standard phase-field approach with spectral decomposition or volumetric-deviatoric (V-D) split leads to unrealistic predictions for the stress transfer through the crack and they have developed a more realistic split for the case of isotropic elasticity and small deformations. The model is constructed from the kinematics of a discrete crack and is further derived to split the crack driving stresses and persistent stresses.

A novel approach based on so-called Representative Crack Elements (RCE) is derived using the kinematics of a discrete crack model. The proposed RCE approach is coupled to the phase-field method by adopting the variational homogenization concept of Blanco et al. [3]. The self consistency condition is employed in order to compare the behaviour of the continuum phase-field model with RCE and a corresponding discrete model. Due to the general variational framework and consistent kinematics, this RCE concept is easily developed for the case of anisotropic material and the coupled problem with temperature (thermo-elasticity).

In this presentation, the phase-field approach with an RCE concept is applied to predict the proposed mixed mode benchmarks. The benchmarks are based on the experiment performed at Carpiuc et al. [5], which consists of the single notch test and the double notch test.

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