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A mixed extended finite element formulation for the simulation of cracks and heterogeneities in nearly incompressible materials

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The efficient and accurate simulation of nearly incompressible materials such as rubber using lower order finite elements can be achieved using mixed methods such as the well known Q1P0 element formulation [1]. During the last years the eXtended Finite Element Method (XFEM) [2] has shown to be an excellent method for the simulation of cracks and their propagation as well as for heterogeneities [3]. Even though the enrichment functions lead to an increased flexibility of the deformation in the vicinity of the crack front and along the crack surface, XFEM simulations based on lower order extended Lagrange finite element formulations may still show locking behaviour for nearly incompressible materials.

In this contribution an extension of the XFEM using a mixed formulation similar to the Q1P0 element is presented. For fracture mechanics applications, elements that are completely intersected by the crack as well as crack front elements require special treatment due to the discontinuity of the displacement as well as the pressure field. Similarly for the simulation of heterogeneities under finite deformations the displacement as well as the hydrostatic pressure field are enriched. By means of several examples it is shown that this mixed extended finite element formulation leads to significantly better convergence rates compared to standard lower order extended finite elements.

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