# Modeling mixed-mode fracture in elastomers at finite strain

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Elastomers are widely applied in automobile industry for rubber tires and tubes. At large deformations, they behave elastically, and the fracture phenomenon is nonlinear. Therefore, mode decomposition is not possible as in the case of linear elastic fracture mechanics [LEFM]. Understanding fracture mechanism in elastomers under mixed-mode conditions is necessary. Recently, experimental studies are conducted on mixed-mode crack propagation in silicone elastomers [1]. The crack propagation for different degrees of mode mixity is reported. Computational modeling helps in studying the effect of mode mixity on mechanical and fracture response of elastomers. Phase field approach is one of the popular methods to model fracture in cracking solids. It has been developed using variational approaches [2]. The total potential energy is minimized to obtain the displacement field and crack phase field using a staggered approach. This approach has been adopted to model fracture in isotropic [3], anisotropic [4], and hyperelastic [5] materials. Mixed-mode fracture criteria can be incorporated into the crack evolution equation using a power law [6]. A thermodynamically consistent phase field formulation for modeling mixed-mode fracture in elastomers is presented. To model elastomers, a nearly incompressible hyperelastic material model is adopted. To model the mixed-mode fracture, a volumetric-deviatoric split is considered, and to ensure the crack doesn't heal, a tension-compression split of the strain energy is also considered. Mixed-mode critical energy release rate is introduced into the crack driving force. A mixed-mode test is conducted on silicone elastomers similar to the material used in experiments in [1]. By varying the degree of mode mixity, the crack angles and mechanical response of the material are plotted. The obtained results are compared with the experimental investigations.

## References

[1] Y. Lu, Y. Qi, M. Tenardi, R. Long, Mixed-mode fracture in a soft elastomer, Extreme Mech Lett 48 (2021) 101380.

[2] B Bourdin, GA Francfort, JJ Marigo, The variational approach to fracture, J Elast 91 (2008) 5– 148.

[3] C. Miehe, F. Welschinger, M. Hofacker, Thermodynamically consistent phase-field models of fracture: Variational principles and multi-field FE implementations, Int J Numer Methods Eng 83 (2010) 1273-1311.

[4] O Gültekin, H Dal, GA Holzapfel, A phase-field approach to model fracture of arterial walls: theory and finite element analysis, Comput Methods Appl Mech Eng 312 (2016) 542-566.

[5] T.C. Gasser, R.W. Ogden, G.A. Holzapfel , Hyperelastic modelling of arterial layers with distributed collagen fibre orientations, J R Soc Interface 3 (2006) 15-35.

[6] H Yu, L Hao, R Shen, L Guo, Z Shen, Y Li , A phase field model with the mixed-mode driving force of power-law relation, Eng Fract Mech 264 (2022) 108265.