
On the finite strain phase field fracture of nearly incompressible hyperelastic material

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Abstract

Rubber-like materials have become integral to the modern society due to their unique properties, such as stretchability, fracture resistance, low cost, ease of manufacture etc. However, predicting the behaviour of such materials especially in fracture becomes inevitable in deciding its suitability for various engineering applications. Thus, some notable studies (1, 2) have already explored the fracture modelling of hyperelastic materials using phase field models. However, the incompressibility of such materials makes the fracture modelling challenging due to the inability of the damaged elements to undergo volume changes. Moreover, the use of the staggered scheme to solve the coupled problem, makes the solution process expensive. The study presented here overcomes both the difficulties while using a mixed displacement-pressure-damage formulation (3) along with a quasi-Newton monolithic solver based on the Broyden–Fletcher–Goldfarb–Shanno (BFGS) technique. The phase field formulation involves the AT2 scheme and the Neo-Hookean hyperelastic constitutive law which decouples the volumetric and isochoric deformation for nearly incompressibility is used here. The algorithm is implemented using a user-defined element subroutine (UEL) in the commercial finite element software ABAQUS. The robustness of the scheme illustrated with the help of three numerical examples, where the results are compared to experiments. Further, the cumulative iteration and computing time of the BFGS solver is compared to that of the staggered solver. The results illustrate a significant reduction in the computing time while requiring a smaller number of iterations to solve the coupled problem. Thus, for the first time we establish the suitability of the BFGS scheme to solve the phase field damage problem of nearly incompressible hyperelastic materials at finite strain.

References

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