A quasi-inextensible element formulation for anisotropic continuum

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ABSTRACT

The contribution presents *a novel finite element formulation* for quasi-inextensible and quasi-incompressible finite hyperelastic behaviour of transeversely anisotropic materials and addresses its computational aspects. The formulation is presented in purely *Eulerian setting* and based on the additive decomposition of the free energy function into isotropic and anisotropic parts where the former is further decomposed into isochoric and volumetric parts. For the quasi-incompressible material response, the *Q1P0-element formulation* is outlined briefly where the pressure type Lagrange multiplier and its conjugate enter the variational formulation as extended set of variables. Using the similar argumentation,an *extended Hu-Washizu type potential* is introduced where the average volume fiber stretch and fiber stress are additional field variables enforcing the quasi-inextensibility constraint. Within this context, the Euler-Lagrange equations and the finite element formulation resulting from the extended variational principle are derived from the extended potential. The numerical implementation exploits the underlying variational structure leading to a canonical symmetric structure. The efficiency of the proposed approached is demonstrated through representative boundary value problems. The superiority of the proposed element formulation over the standard Q1- and Q1P0-element formulation is studied through benchmark convergence analyses. The proposed finite element formulation is modular and shows excellent performance for fiber reinforced elastomers and anisotropic biological tissues in the inextensibility limit.

References

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