The effect of a consistent linearization on the numerical stability of hybrid-elements for quasi-incompressible hyperelastic solids

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ABSTRACT

The numerical ill-posedness of irreducible (purely displacement-based) finite element formulations for quasi-incompressible materials requires the usage of mixed formulations extended by additional primary unknowns instead. In the talk, we revisit the well-known three-field formulation introduced by Simo and Taylor, [1]. However, while in [1] a semi-discretization is used to eliminate the additional primary unknowns before the problem is linearized in terms of the not yet discretized displacement field, we introduce a consistent linearization of the three-field formulation on the continuum-level. In the latter case, static condensation is used to eliminate the additional unknowns on the element-level after the linearization of the continuum formulation in order to derive discontinuous hybrid-elements.

A family of Simo-Taylor-Pister (STP) elements, as well as a family of elements based on the continuum-level linearization (CL3F), designed to coincide in terms of the interpolation scheme, the number of assembled degrees of freedom and the number of integration points with the Abaqus hybrid-elements (C3D8H, C3D20H, C3D10H) are compared to those elements by benchmark tests. Material parameters were obtained by least-square fitting to experimental data of an industrial NR/IR-blend (natural rubber / isoprene rubber) used for damping applications.

All elements are locking-free. The STP-elements show the known severe stability issues. In general the maximum stable step-width of the Abaqus hybrid-elements is way higher in comparison to the STP-elements. However, the CL3F-elements outperform the Abaqus elements in general without the usage of numerical stabilization. Especially in combination with nonlinear compression models the advantage of the CL3F is huge - here the stable step-width is up to 22-times larger. Details can be found in [2].

REFERENCES
