A uniform nodal strain tetrahedron with isochoric stabilization

Abstract:
A stabilized node-based uniform strain tetrahedral element is presented and analyzed for finite deformation elasticity. The element is based on linear interpolation of a classical displacement-based tetrahedral element formulation but applies nodal averaging of the deformation gradient to improve mechanical behavior, especially in the regime of near-incompressibility where classical linear tetrahedral elements perform very poorly. This uniform strain approach adopted here exhibits spurious modes as has been previously reported in the literature. We present a new type of stabilization exploiting the circumstance that the instability in the formulation is related to the isochoric strain energy contribution only and we therefore present a stabilization based on a isochoric-volumetric splitting of the stress tensor. We demonstrate that by stabilizing the isochoric energy contributions only, reintroduction of volumetric locking through the stabilization can be avoided. The isochoric-volumetric splitting can be applied for all types of materials with only minor restrictions and leads to a formulation that demonstrates impressive performance in examples provided.