Curl-free Finite Elements for gradient elasticity at finite strains

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Gradient elasticity formulations can be used to model specialized materials, whose elastic behavior depends on size relations between the microstructure and specimen size. Through enrichment of the internal elastic energy by a higher order gradient term, which contains additional constitutive parameters, these so called size effects can be captured. Moreover, singularities at e.g. sharp corners of the modeled specimen, which would appear in classical elasticity formulations are avoided and corresponding numerical simulations have the advantage of remaining mesh objective. However, a straightforward discretization requires C1-continuity, for which retaining compatibility with standard software and meshing arbitrary structures are known difficulties. Another approach is to use mixed formulations instead. They have the advantage of a relaxation of continuity requirement to C0 and making standard finite element discretizations possible. So far, a common approach is to make both displacements, displacement gradients and additional Lagrange multipliers seperate discretization variables leading to finite elements with a relatively high number of degrees of freedom. The present contribution investigates a stable approach in which the displacements are decoupled from the formulation shrinking the size of the problem. Moreover, further cost reduction through reduced numerical approaches eliminating the lagrange multiplier variable are investigated and comparative studies are presented.

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