The role of physical constants in nonlinear micropolar elasticity at finite strains

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Abstract

A geometrically nonlinear formulation of the physically linear micropolar elasticity theory is investigated numerically using mixed finite elements in the open-source software FEniCSx, formulated in the Lagrangian reference frame. The micropolar continuum theory introduces additional rotational degrees of freedom, along with six elastic parameters in an isotropic formulation. While a good physical intuition has been established for these parameters within a geometrically linear framework of small deformations, no such understanding exists for a framework incorporating large deformations. Since micropolar theories have proven effective for materials such as foams, which can undergo large deformations without damage, further investigation is warranted. The physically linear material law for large deformations, generalized from the law for small deformations, retains the same form as the St. Venant-Kirchhoff law in classical elasticity. However, it does not directly correspond to the classical formulation, as the strain measures differ in nature. A comparison of the two formulations is presented. The numerical implementation is validated against available three-dimensional analytical solutions. The problems of cylindrical bending and torsion of a beam as well as the torsion of a cylinder are revisited, with a special focus on the physical meaning of the elastic constants.

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