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Finite Element Analysis of Internally Balanced Elastic Materials

A. Hadoush^{a,1,*}, H. Demirkoparan^a, T. J. Pence^b

^a*Carnegie Mellon University in Qatar, Qatar*

^b*Dept. Mechanical Eng., Michigan State University, USA*

Abstract

This paper provides a finite element treatment for a generalized hyperelastic theory in which the deformation gradient is subject to the multiplicative two-factor decomposition that is commonly used in large strain plasticity. The multiplicative decomposition in the present context is motivated by a theory of balanced internal variables, one of which is the first factor in the decomposition. Previous studies have shown how the associated continuum mechanical formulation then leads not only to the stress equations of equilibrium but also to an additional tensor balance equation that serves to determine the individual factors in the decomposition. Such a theory has been shown to predict loading thresholds associated with the emergence of slip surfaces at grip locations in well-posed boundary value problems. However, previous numerical treatments focused on shooting method procedures that failed to resolve loading plateaus and other key features associated with the emergence of such singular surfaces. In the present work we describe a finite element treatment that resolves such previously obscure details. Additional finite element simulations illustrate new aspects of singular surface emergence in this type of theory, including the emergence of singular surfaces in the interior of the computational domain.

Keywords: Elasticity, Internal balance, Finite element, Multiplicative decomposition, Slipping surfaces

*Corresponding author

Email addresses: ahadoush@qatar.cmu.edu (A. Hadoush), hasand@andrew.cmu.edu (H. Demirkoparan), pence@egr.msu.edu (T. J. Pence)

¹Present address: Dept. Mechanical Eng., Palestine Technical University-Kadoorie, Palestine

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