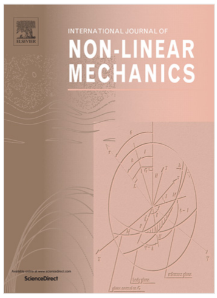
Accepted Manuscript



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PII: S0020-7462(17)30833-8
DOI: https://doi.org/10.1016/j.ijnonlinmec.2018.04.002
Reference: NLM 2998

To appear in: *International Journal of Non-Linear Mechanics*

Received date : 15 December 2017
Revised date : 27 March 2018
Accepted date : 1 April 2018

ON THE DYNAMIC DILATATION OF A COMPRESSIBLE RIVLIN CUBE BEYOND ITS ELASTIC LIMIT

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Abstract
When an isotropic hyperelastic unit cube subjected to dynamic tri-axial extension/compression dilates successfully beyond its elastic limit, namely into its work-hardening deformation regime, plastic flow transforms any kind of induced into permanent anisotropy. If, for instance, two pairs of forces are identical while the third pair is different, then the initially isotropic material properties will transform permanently into those of transverse isotropy. For this problem, a plasticity model is presented that enables the energy stored during the work-hardening deformation stage of the resulting cuboid to be influenced not only by a tensorial measure of the observed deformation, but also by a measure of the plastic flow that takes place simultaneously. The model considers that plastic flow still obeys conventional plastic yield criteria, but does not postulate *a-priory* a rule that splits the observed deformation into elastic and plastic parts. Derivation of constitutive equations is based instead on the postulate that the strain energy density of the material is a function of the deformation gradient tensor and either the rate-of-plastic-deformation tensor encountered during loading within the work-hardening deformation regime or the residual strain tensor encountered after unloading is completed from some relevant offset yield point. An example application presents a complete analytical solution to the deformation problem of a dynamically loaded Rivlin cube which is made initially of a compressible Rivlin-Mooney material.

Keywords: Constitutive equations, Dilatation beyond elastic limit, Hyperelasticity, Induced anisotropy, Mooney-Rivlin material, Plasticity, Residual strain/stress, Rivlin's cube, Work-hardening plasticity, Yield condition.

1. Introduction

The classical problem of the Rivlin cube [1] refers to the stability and uniqueness/non-uniqueness of the dilatation states of an isotropic, incompressible hyperelastic unit cube which is acted upon by three identical pairs of equal and oppositely directed forces, $\pm f$, applied normally to its faces and distributed uniformly over them. The considerable number of relevant studies that followed [1] may be traced through a relatively smaller set of more recent publications [2-8], all of which dealt with stability and uniqueness/non-uniqueness of the dilatation states of a corresponding compressible hyperelastic cube.

This investigation aims to initiate a study of the dilatation states of an initially isotropic, hyperelastic and compressible unit cube which (*i*) develop in a dynamic manner, and (*ii*) reach and exceed the elastic limit of the cube material before any kind of possible material instability interferes with the deformation. Such dilatation states are expected to remain intact even after initial yield of the cube material takes place, namely within the work-hardening dilatation regime where elastic deformation and plastic flow take place simultaneously.