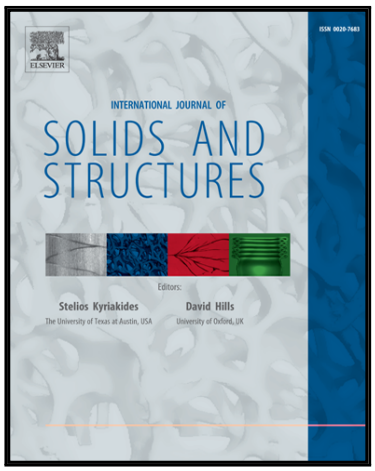

New multi-axial constitutive models for large elastic deformation behaviours of soft solids up to breaking

Heng Xiao, Xie-Fei Ding, Jie Cao, Zheng-Nan Yin

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New multi-axial constitutive models for large elastic deformation behaviours of soft solids up to breaking

Heng Xiao[1], Xie-Fei Ding, Jie Cao, Zheng-Nan Yin

Shanghai Institute of Applied Mathematics and Mechanics and State Key Laboratory for Advanced Special Steels, Shanghai University, Yanchang Road 149, Shanghai 000072, China

A hyperelastic model is proposed to characterize large elastic deformation behaviours of soft solids. Novelties in four respects are incorporated in this model, namely, (i) general compressible deformations may be treated and, accordingly, the usually-assumed incompressibility constraint and associated issues may be bypassed; (ii) applicability for all kinds of material samples may be automatically ensured, in the sense that any given test data for three deformation modes may be exactly fitted, including uniaxial, equi-biaxial and plane-strain extension; (iii) model parameters of direct physical meanings may be provided to characterize both strain-stiffening and softening effects; and (iv) breaking behaviour may be simulated. Numerical results for model validation are in good agreement with Treloar's classic data for rubbers and with extensive data for various kinds of polymer gels.

Keywords: Soft solids, Large deformation, Strain-stiffening, Softening, Hyperelastic model

1 Introduction

Recently, much attention has been directed to experimental and theoretical investigations into large elastic deformation behaviours of soft solids, in particular, various kinds of elastomers and polymer gels. Most recent results in investigating linear and nonlinear elastic behaviours of soft solids are presented for gelatin gels (Bot et al. 1996), gellan gels (Tang et al. 1997), WPI/DX mixed gels and WPI/DX conjugate gels (Ribeiro et al. 2004, Spotti et al. 2013), extremely soft polymer gels (Yohsuke et al. 2011) and hydrogels (Drozdov and Christensen 2013b). Moreover, certain representative results for rubberlike materials may be found in the review articles (Beatty 1987, Boyce and Arruda 2000, Horgan and Saccomandi 2006, Ogden et al. 2006). Further references for most recent results will be given slightly later.

Experimental characterization of nonlinear elastic behaviours of soft solids serve as an indispensable basis for cablirating and validating various hyperelastic models for soft solids. As usual, test data are supplied for several benchmark tests, including uniaxial, equi-biaxial and plane-strain extension as well as simple shear. Usually, stress-strain data are measured up to certain large strains prior to breaking. Refer to Treloar (19975) and Jones and Treloar (1975) for classic data for rubbers and to the references in the

[1]Corresponding author. Tel.:+86-21-56331577. Email: xiaoheng@shu.edu.cn