FAILURE SURFACES FOR FINITELY STRAINED POROUS ELASTOMERS UNDER ARBITRARY IN-PLANE LOADING

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The present work studies the connections between microstructural instabilities and their macroscopic manifestations — defined as the loss of rank-one convexity of the effective properties — in finitely strained porous elastomers with a) random isodisperse and b) periodic microstructures. The powerful second order homogenization (SOH) approximation technique, initially developed by P. Ponte Castaneda for random media, is also used here to study the onset of failure for periodic microstructures and the results are compared to more accurate finite element method (FEM) calculations.

The influence of microgeometry (random and periodic with square and hexagonally arranged pores), initial porosity, matrix constitutive law (neo-Hookean and Gent) and macroscopic load orientation on the microscopic instability (loss of uniqueness of the principal solution for the case of periodic microstructures) and the macroscopic instability (loss of rank-one convexity of the homogenized energy density for all microstructures) is investigated in detail. In addition to the above-described stability-based onset of failure mechanisms, limitations to the elastomer's response at finite strains (such as void surface instability, percolation, pore closure and strain locking) are also addressed, thus giving a complete picture of the different possible failure mechanisms present in finitely strained porous elastomers.