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Finite-volume homogenization and localization of nanoporous materials with cylindrical voids. II: New results. (English) Zbl 1406.74556

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Summary: The finite-volume homogenization theory with surface-elasticity effects based on the Gurtin-Murdoch model developed in Part 1 [the authors, ibid. 70, 141–155 (2018; Zbl 1406.74557)] is employed to investigate little explored aspects of nanoporous materials' response. New results illustrate the effects of pore array architecture, aspect ratio and mean radius of elliptical porosities on local stress fields and homogenized moduli in an admissible range of porosity volume fractions. These results highlight the importance of adjacent pore interactions neglected in the classical micromechanics models, quantified herein for the first time. The theory is also shown to capture the highly oscillatory stress fields associated with surface-elasticity induced solution instabilities in this class of materials with negative surface moduli without ill-conditioning problems. Differences and similarities between comparable finite-element and finite-volume solutions of the unit cell boundary-value problem are delineated, including identification of pore radii, and associated aspect ratios and volume fractions, at which instabilities initiate. Consistent with reported and herein generated finite-element based results, the solution instability is also shown to depend on finite-volume mesh refinement. Hence care is required to identify the admissible range of parameters in the calculation of homogenized moduli. The new theory provides an alternative and independent means of identifying stable solution ranges, and hence is a good tool in assessing the finite-element method's predictive capability of generating stable solutions. Comparison with molecular dynamics simulations is included in further support of the theory's potential to capture both the initial homogenized response and local stress fields that may lead to failure.

MSC:

74Q05 Homogenization in equilibrium problems of solid mechanics
74F10 Fluid-solid interactions (including aero- and hydro-elasticity, porosity, etc.)
74M25 Micromechanics of solids
74S10 Finite volume methods applied to problems in solid mechanics

Keywords:

nanoporous materials; elliptical porosities; surface-elasticity effects; finite-volume homogenization; homogenized moduli; local stress fields; surface instabilities

Software:

sPuReMD

Full Text: DOI

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