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Nanoporous materials with a general isotropic plastic matrix: exact limit state under isotropic loadings

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Abstract

In this paper, hydrostatic strength properties of nanoporous materials are investigated by addressing the limit state of a hollow sphere undergoing isotropic loading conditions. Void-size effects are modelled by treating the cavity boundary as a coherent-imperfect homogeneous interface. The hollow sphere is assumed to be comprised of a rigid-ideal-plastic material obeying to a general isotropic yield criterion. The latter is defined by considering a simplified form of the yield function proposed by Bigoni and Piccolroaz in [Int J Solids Struct; 41: 2855–2878], resulting able to account for a broad class of pressure-sensitive materials whose plastic response is also affected by the stress Lode angle. The corresponding support function is consistently derived and discussed. The exact solution of the limit-state problem is fully determined, providing a closed-form description of stress, strain-rate and velocity fields, as well as the macroscopic hydrostatic strength of nanoporous media. Proposed approach allows to consistently generalise available analytical solutions for porous and nanoporous materials, by accounting for a general plastic response of the solid matrix and for void-size effects. Finally, present exact solution, as well as the identification of the support function for the adopted general strength criterion, open towards novel kinematic limit-analysis approaches for describing macroscale strength properties of nanoporous materials under arbitrary triaxial loadings.

Keywords: Nanoporous materials, strength properties, hollow-sphere model, general isotropic plastic matrix, support function, void-size effects.

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