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Void coalescence in porous ductile solids containing two populations of cavities

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Abstract

A model of coalescence by internal necking of primary voids is developed which accounts for the presence of a second population of cavities. The derivation is based on a limit-analysis of a cylindrical cell containing a mesoscopic void and subjected to boundary conditions describing the kinematics of coalescence. The second population is accounted locally in the matrix surrounding the mesoscopic void through the microscopic potential of Michel and Suquet (1992) for spherical voids. The macroscopic criterion obtained is assessed through comparison of its predictions with the results of micromechanical finite element simulations on the same cell. A good agreement between model predictions and numerical results is found on the limit-load promoting coalescence.
Keywords: Ductile materials; Void coalescence; Limit-analysis; Double porous materials; Plastic compressibility

1 Introduction

Ductile failure is one of the most dominant mode of failure of metallic alloys at room temperature. It is well recognized that failure is essentially controlled by the nucleation, growth and coalescence of *primary* voids (Benzerga and Leblond, 2010; Benzerga et al., 2016; Pineau et al., 2016). Those primary voids usually nucleate on large inclusions by particle cracking or interface decohesion, and then grow by diffuse plastic deformation without notable interactions with neighboring cavities. When the onset of coalescence is reached, plastic deformation becomes localized between neighboring primary voids, which accelerates the failure mechanism leading ultimately to the final fracture. It has been shown that the nucleation and growth of *secondary* voids in aluminum alloys and in steels quicken the damage process of primary voids and thus lead to a reduction of ductility

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