

Approximate lower bound yield criterion for anisotropic porous solids

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In the present investigation we are concerned with the anisotropic plastic behavior of porous ductile materials. We consider a Hill type anisotropic matrix containing spherical voids and we aim to account for the overall plastic anisotropy and derive a new yield criterion.

The originality of this work is to attempt to develop an approximate lower bound macroscopic criterion. For this purpose we proceed by a statical limit analysis procedure in the light of the recent work of Cheng et al. ¹ which was initially proposed for isotropic von Mises matrix. A trial stress field is thus used for the derivation of the new yield loci. Interestingly, the obtained quasi-lower bound criterion is macroscopically anisotropic and shows the influence of both the plastic anisotropy of the matrix, the first and second invariants of the macroscopic stress and the sign of the third invariant of the stress deviator (J_3). The corresponding yield surface is slightly asymmetric with respect to either the deviatoric ($\Sigma_m = 0$) or hydrostatic ($\Sigma_e = 0$) axis. The obtained results are discussed and compared to existing theoretical models, namely the upper bound yield criterion of Benzerga et al. ², numerical data given by Pastor et al. ³ and to recent Finite Elements results of Morin et al. ⁴. Finally, we provide the plastic strain rate equations and the void evolution law which is crucial for predicting the failure of ductile metals. The influence of the plastic anisotropy on these constitutive equations is shown.

In the figure below we compare the yield curves according to the new criterion and corresponding to $J_3 > 0$ and to $J_3 < 0$ with those pertaining to Benzerga et al. for a porosity $p = 0.05$ and $p = 0.1$ respectively. The zoom on a portion of the figure displays a slight asymmetry of the yield surface.

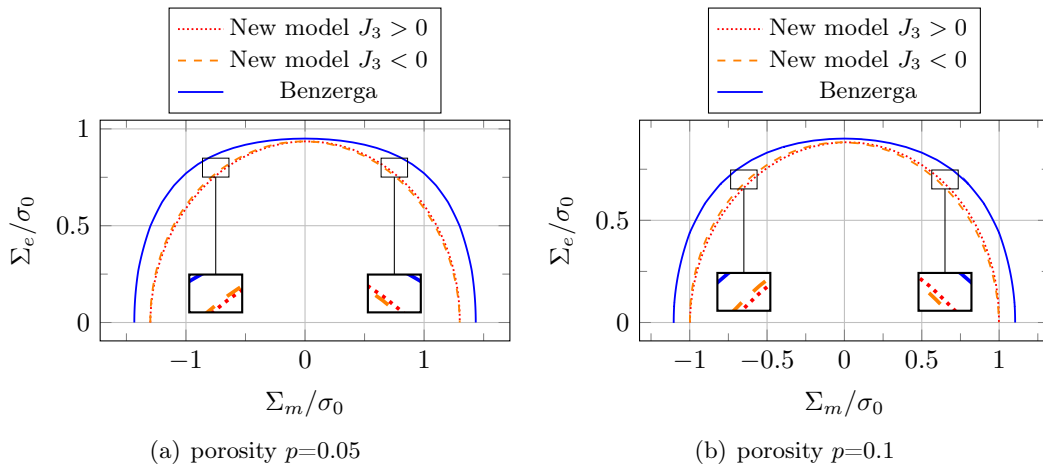


Figure 1: Hill matrix: comparaison of the yield surfaces given by the proposed new criterion and by Benzerga et al.

¹L. Cheng, G. de Saxcé, D. Kondo, *Int. J. Plast.* **55**, 133-151 (2014)

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³F. Pastor, J. Pastor and D. Kondo, *C. R. Mecanique*, **340**, 120-129 (2012)

⁴L. Morin, K. Madou, J-B. Leblond and D. Kondo, *Int. J. Eng. Sci.*, **74**, 65-79 (2014)