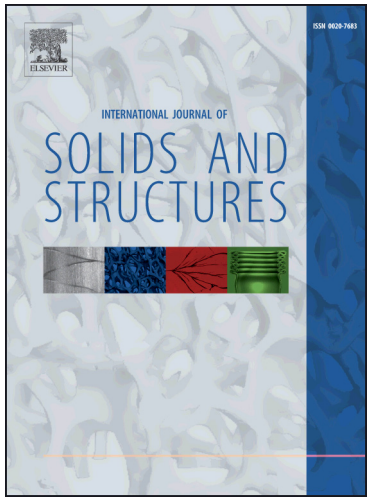

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STUDY OF LOCALIZATION IN A VOID-SHEET UNDER STRESS STATES NEAR PURE SHEAR

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ABSTRACT – A recent study of a porous ductile material under pure shear has indicated that no failure is predicted, whereas a number of micro-mechanical analyses for simple shear have shown that a maximum shear stress is reached and failure occurs. Both simple shear and pure shear are characterized by zero stress triaxiality and in both types of stress states the analyses show that the voids collapse to micro-cracks. The possibility of failure in pure shear is further investigated here by studying the effect of an initial imperfection in the form of a row of circular cylindrical voids inclined to the principal tensile stress. A number of previous investigations have shown that such imperfections can lead to plastic flow localization in a shear band and subsequently lead to void- sheet fracture inside the band. The present analyses confirm that the imperfection results in localization failure, even at moderate or rather low stress triaxiality. But in pure shear, with zero stress triaxiality, no failure is predicted. Initially the imperfection results in increasing shearing along the row of voids, but this tendency towards increasing shearing is interrupted if the voids collapse to micro-cracks. For the largest imperfection considered, i.e. a relatively large ratio of the void radius to void spacing, there is still a range of stress states in the vicinity of pure shear, where no localization is predicted, and for smaller imperfections this range is larger.

KEYWORDS: Voids, low stress triaxiality, large strain plasticity, contact, pure shear.

1. INTRODUCTION

In ductile metals fracture typically occurs by the nucleation of voids that subsequently grow to coalescence. Sometimes, when shear localization takes place before final failure, voids grow to coalescence while they are being smeared out in what is called void-sheet failure. Such void-sheet failure was early observed in experiments (Rogers, 1960). In early applications of the Gurson model it was found that shear localization is predicted (Yamamoto, 1978; Tvergaard, 1981; Saje et al., 1982) resulting in subsequent void-sheet failure, both in cases where the bands initiate at a bifurcation from a homogeneous stress state and in cases where they grow from an imperfection. For a metal with two populations of voids the Gurson model has been used (Tvergaard, 1982) to show the failure mechanism, where localization occurs between two larger voids, leading to local void-sheet failure between the larger voids. There has also been numerical studies for a single layer of voids in a ductile solid (Tvergaard, 1989; Barsoum and Faleskog, 2011; Tekoglu et al., 2014), which directly show that this imperfection can result in void-sheet failure. Many research articles on ductile fracture