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Finite Element Lüders Band Modelling : Influence of Material and Geometrical Parameters

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1 Introduction

The sharp yield point phenomenon was discovered during 19th century by Piobert and Lüders [Piobert, 1842, Lüders, 1860]. This latter is due to strain ageing and occurs in many metals during the transition between elastic and plastic deformation. This transition is characterized by a material instability inducing a non homogeneous plastic deformation. A band of localized plasticity nucleates at the peak stress, and propagates at a constant global stress level on the Lüders plateau. This band is generally oriented at an angle of approximately 54°with the tensile direction. At the end of this latter the deformation becomes homogeneous again [Marais et al., 2012, Mazière and Forest, 2015]. The aim of this work is to investigate the influence of the material and geometrical parameters on the nucleation and propagation of a Lüders band during finite element simulations.

2 Influence of yield criterion

The localisation angle observed during finite element simulations of Lüders band propagation can be predicted using analytical results [Rice, 1976]. This prediction works well for usual von Mises plasticity but some unexpected results can be observed with other yield criteria like for example a close to Tresca one. Many yield criteria (von Mises, Tresca, Hosford, elliptic, GTN, Rousselier, Hill,...) have been tested in this work in order to outline their influence during finite element simulations of tensile plates on :

- The location and rapidity of the band nucleation
- The angle and width of the localisation propagating band

2 Influence of thickness

It has been shown in some recent articles [Marais et al., 2012, Mazière and Forest, 2015] that finite element simulations of Lüders bands using 2D plane stress models provide some highly mesh dependent results. This dependency is less obvious for 3D simulations for which the specimen thickness seems to play an important role (see figure 1). Many different specimen geometries have been simulated in this work in order to investigate the influence of section shape on the band nucleation and propagation. In particular, different mesh sizes have been tested for each geometry in order to evaluate the geometrically induced regularization.

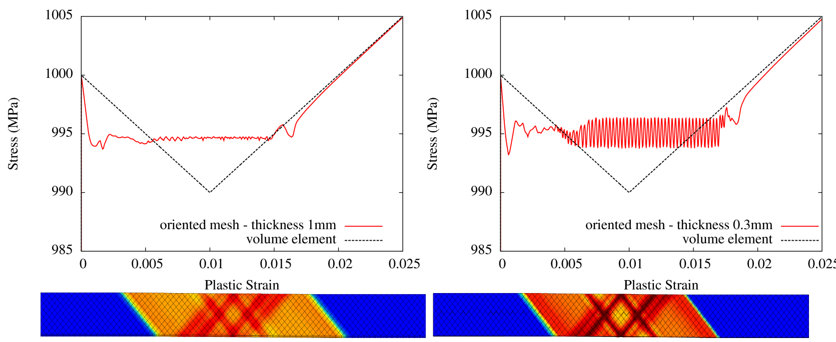

Figure 1: Finite element simulations of a Lüders band propagation for a 1.mm (left) and a 0.3mm (right) tensile plate.

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