**8th. World Congress on Computational Mechanics (WCCM8)**
**5th European Congress on Computational Methods in Applied Sciences and Engineeering (ECCOMAS 2008)**
**June 30 –July 5, 2008**
**Venice, Italy**

# Three dimensional implementation of non-local ductile damage and fracture modelling

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**Key Words:** *Ductile damage, Hyperelasto-plasticity, Softening, Fracture, Non-local damage.*

## ABSTRACT

Ductile damage plays a significant role in almost all metal forming processes which induce reasonably large strains. In some cases, like e.g. cutting, this phenomenon is used in order to achieve a product shape; but in most cases the goal is to avoid damage as much as possible. It has been reported that the ductile failure process in polycrystalline metals generally involves porosity initiation, porosity growth/coalescence and localized deformation in various combinations, dependent upon material type and boundary conditions. The focus of this research is to properly model the macroscopic material response under different loading conditions without explicitly modeling all micro-mechanisms.

Mediavilla et al. [1] proposed a nonlocal triaxiality-dependent ductile damage model for finite strain plasticity. In this model damage affects both the elastic stiffness and the yield stress through a scalar damage variable. Two dimensional crack propagation was also implemented using the above mentioned model in a way that damage grows and when it reaches a critical value a crack is inserted; the crack subsequently propagates according to the damage field in front of the crack tip [2].

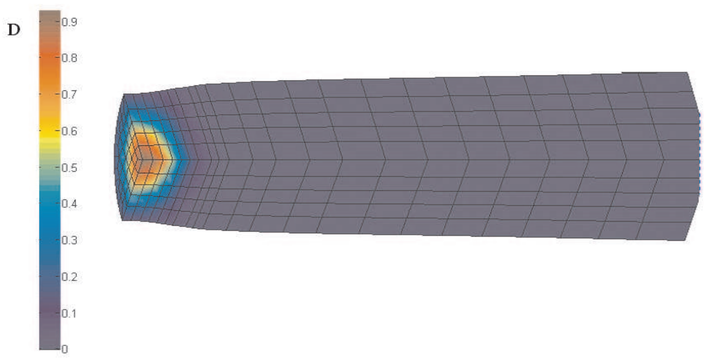


Figure 1: Damage distribution in one eighth of a cylindrical sample.

The implementation presented in [1] is essentially two-dimensional. In the present contribution we discuss steps taken to extend the implementation to three dimensions. Whereas many aspects of the modelling and implementation can remain unchanged, this extension requires two major new developments.

The first is the development of reliable three-dimensional elements for the coupled damage-plasticity model which do not show locking or instabilities. Figure 1 shows a result obtained using brick elements which are akin to the quadrilateral elements used by Mediavilla [1]. The figure shows the predicted damage distribution in a tensile bar of which only one eighth has been modelled using the appropriate symmetry conditions. To allow the use of automatic (re-)meshing complex shapes in three dimensions, however, it is necessary to have a reliable tetrahedral element; in the present contribution we develop such an element.

A second necessary development is the extension of the crack growth algorithm to complex, three-dimensional evolving geometries. As a starting point an algorithm has been developed for a small deformation, three-dimensional damage-driven crack modelling (Figure 2). Like in the two-dimensional framework, [2] the damage field in front of the crack is used to determine the direction of crack growth.

Both aspects of the extension to three dimension will be illustrated by numerical examples.

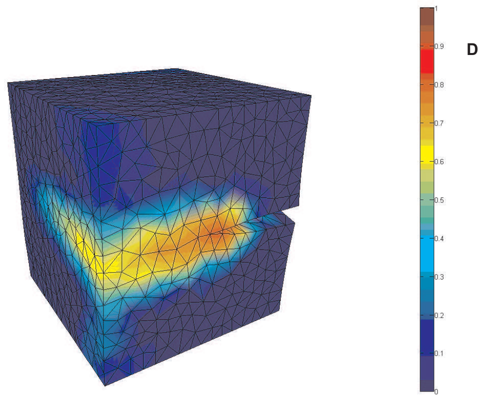


Figure 2: Three dimensional damage-driven crack propagation.

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