A tri-dimensional model for the numerical treatment of ductile fracture in dynamics using the Extended Finite Element Method

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Abstract

Summary

The purpose of this work is to extend the tri-dimensional unified methodology used to reproduce the different phases of ductile fracture proposed by (1) in order to solve transient dynamic problems while treating the effects linked to large deformation. A particular attention will be paid to the mass matrix definition in the context of the extended finite element method (XFEM) as well as the way high strain rates effects are taken into account in the material constitutive behavior. Exemples of simulations using both implicit and explicit integration schemes are presented.

Introduction

It is generally accepted that the ductile fracture process that is initiated within a material more or less lately after the plastic flow start can be divided into 3 phases : (i) diffuse damage by nucleation and growth of voids, (ii) strain localization in a narrow band and (iii) initiation and propagation of a macro-crack. The strain localization process is tentatively put aside in this work, a direct transition between diffuse damage and crack propagation is indeed considered. Such a scenario of the ductile fracture process is similar to the one proposed by (2). The material is supposed to obey to the micro-porous plasticity model proposed by Gurson and modified by Tvergaard and Needleman (3) and its hardening is represented by a Voce type law. The extended finite element method (XFEM) is used for the numerical treatment of the crack. A lumped mass matrix is generally used to solve dynamic problems, allowing to minimize the computation time by, notably, increasing the stable time increment (4). A lumping scheme of the mass matrix in the context of the shifted basis of the XFEM (5) is presented with the aim of ensuring the kinetic energy conservation (6).

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Validation of the model

The proposed model was implemented via a user element in the commercial finite element computation software Abaqus (UEL or VUEL depending on the integration scheme) and used to carry dynamic tests on CT specimens using both time integration schemes. The results are then compared in term of crack profiles, porosity fields, stiffness evolution and energy balance.

References

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