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Simulation of the failure of ductile materials under dynamic loading using continuum damage models with micro-inertia

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The understanding and modelling of the failure of ductile materials under dynamic loading conditions is an important issue for several applications, like the safety of pressurized structures (aircraft and gas pipelines), and the resistance of protective structures and shieldings to ballistic impacts and explosions. Damage in ductile solids is induced by the diffuse nucleation and growth of microscopic voids. The softening effect due to damage may lead to strain localization, promoting the damage development and leading to the formation of a crack, which can propagate through the specimen.

The proposed talk deals with the simulation of the initiation and propagation of cracks under dynamic loading using continuum damage models. The aim of the presentation is to present a new micromechanical approach to dynamic damage by micro-voiding. This model represents an extension of Gurson-like damage models [1] for dynamic loading conditions. An original feature of the proposed constitutive framework is to take inertial effects due to void growth into account. Because micro-inertia leads to the introduction of a characteristic microstructural length scale in the modelling (micro-inertial effects depend on the distribution of void sizes within the material), it is not possible to use the sole porosity to describe the state of damage. The present model is based on three physical parameters: the porosity, the number of voids per unit volume and an internal variable aiming to represent the effect of void size heterogeneity [2]. The proposed modelling has been applied to investigate the dynamic fracture of several specimens. In all cases, it was observed that micro-inertia has a strong influence on the crack growth behaviour. Since micro-inertia prevents damage to develop too rapidly, a regularizing effect is observed which reduces the mesh sensitivity of the simulations. Micro-inertia was also found to lead to lower crack speed and higher fracture toughness [3].

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