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COMPUTATIONAL TREATMENT OF DYNAMIC PENETRATION ACCOMPANIED WITH ADIABATIC SHEAR BANDING

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ABSTRACT

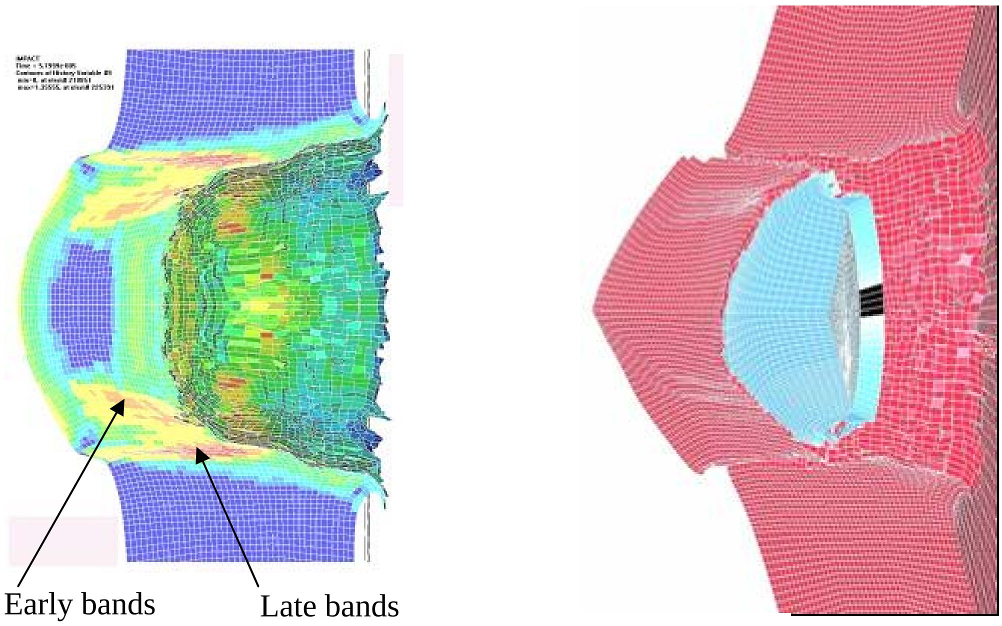
In some engineering applications, notably those implying detailed analysis of consecutive phases for impacted metallic structures with the predominant failure mechanism triggered by adiabatic shear banding (ASB), a three-dimensional insight and treatment are desirable. They are scarce in the literature as the relative modelling should be rigorous enough and robust as well to incorporate and overcome local instabilities relative to inception and growth of ASB. The modelling approach proposed is based on the choice of the reference representative volume element (RVE) whose length scale is much greater than the bandwidth, while many existing works consider in fact a length scale lower than the bandwidth.
In this context, a thermoelastic/viscoplastic constitutive model has been built, incorporating thermomechanical hardening/softening competition and the ASB-induced degradation and anisotropy in the finite deformation framework (see [1] for further details). The model is implemented as user material in the engineering computation code LS-DYNA. Integration of constitutive equations in the case of softening behaviour is not trivial, and there is no standard procedure. It is well-known that viscosity contributes to 'regularize' the boundary value problem but in the present case (strong localization induced by ASB formation) a complementary procedure was needed to overcome numerical locking in the context of explicit scheme. The adaptive time step procedure adopted is based on the principle of the maximal strain increment and consists in sampling, i.e. partitioning, the 'global' time increment (the time increment determined by the code itself for integrating the equations of motion). By reducing the 'local' time increment (the time increment used for integrating constitutive equations), i.e. for the element concerned and not for the whole structure, it ensures numerical convergence and stability.

The numerical results relevant to various configurations of hat shape structure (HSS) under dynamic shearing, leading to partial or complete banding (and subsequent failure) depending on the shock intensity, are examined and compared with experimental data

(see [2] for detailed analysis). A tentative, ASB-induced local failure criterion is being inferred from the corresponding analysis and experimental evidence. The HSS problem investigation is viewed here as a stage towards genuine ballistic engineering problems where the ASB trajectories cannot be known a priori.

A particular problem of this kind is being dealt with, involving an interaction of a fragment simulating projectile (FSP) and a semi-thick plate target. A three-dimensional numerical study is summarized for shock configurations below and above the ballistic penetration limit velocity V_{bpl}. The thermoelastic/viscoplastic/ASB deterioration model (TEVPD) employed allows for bringing out complex ASB-related history regarding impacted plate material.

From the numerical standpoint there is no need to know a priori the band trajectory neither to refine finite element meshing for areas crossed by bands. Thanks to the regularizing effects produced by material scale postulate, the double viscosity (viscoplasticity and viscous ASB-degradation) and an adaptive time step procedure, only slight mesh size dependence is observed in the post-localization (softening dominated) stages.



a) V_{FSP}/V_{bpl}=95%
Deterioration map in deformed view

b) V_{FSP}/V_{bpl}=105%
Deformed view

Fig. 1 : Numerical views of the deformed plate for FSP initial velocity V_{FSP} lower and higher than the ballistic penetration limit velocity V_{bpl}

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