On Various Numerical Simulation Techniques for Perforation of Concrete Panel by Hard Projectile

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ABSTRACT

This paper presents different numerical simulations of perforation process of a concrete slab impacted by a high-speed steel projectile. Perforation is a highly dynamic event. Results are obtained by different numerical methods, including the Finite Element Method (FEM), Finite Different Method (FDM), Discrete Element Method (DEM) and one of the meshless method called "Smooth Particle Hydrodynamics" (SPH). Their merits and demerits will be illustrated and discussed.

In the numerical simulations, a multi-surface stress-state model, which is a dynamic plastic-damage constitutive model, is developed to model the concrete target. Prior to failure, the multi-surface strength model is based on a modified Unified Twin Shear Strength (UTSS) theory, which takes into account the effect of intermediate shear stress. The UTSS theory together with some empirical formulae leads to the initial yield surface, loading surfaces and the failure surface. Beyond failure, damage parameters are introduced and residual strength surfaces are constructed to define the damaged material. The damage scalar depends on an equivalent plastic strain. The model is incorporated into available commercial software through its user-defined-function. This model is capable to yield reasonable predictions of the highly dynamic event.

However, the capability of the continuum models is limited. The intrinsic assumptions prevent it from reproducing some phenomena often observed during the field tests, such as concrete spalling at the impact face, scabbing at the rear face, and shear plug formation ahead of the projectile. Against this background, the capabilities of discrete model are highlighted. Illustrative examples are included.