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Numerical analysis of high velocity impact penetration problems

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Abstract

High velocity impact penetration problems involve complicated mechanics such as projectile-target contact interaction, target (probably projectile as well) damage and failure, debris evolution (which is of great interest in many applications) after failure, etc. Very high strains and strain rates, large degrees of damage and material separation, and complex contact conditions are involved in these problems. Numerical solutions for these problems are generally non-smooth and the discrete governing equations often become ill-conditioned. However, a robust numerical approach is yet to be developed.

To solve this type of problems, several approaches are investigated in this study. For the Lagrangian finite element method (FEM), mesh distortion occurs inevitably, which leads to low accuracy and numerical instability. In addition, to trigger material separation, artificial erosion needs to be introduced and it is difficult to track the debris evolution due to its dependence on element connectivity. On the other hand, meshfree method can provide a natural way to track the debris evolution due to its particle property without introduction of erosion. Therefore, FEM is enriched with meshfree formulation to enhance its capability in solving these problems while not losing too much of its efficiency [1]. However, the numerical analyses showed that zero energy modes might be activated if the meshfree weak formulation is integrated by Gauss quadrature with hexagonal grids. It was further identified that zero energy modes are largely suppressed if a stabilized conforming nodal integration (SCNI, [2, 3]) is applied. With the meshfree enrichment, the formulation can solve impact penetration problems (impact velocity up to 3000 m/sec) reasonably well in the Lagrangian framework.

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