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Multi-scale Modeling of High Velocity Impact on Alumina Ceramic Tiles

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ABSTRACT

Multi-scale numerical modeling informed and validated by experiments is a powerful engineering tool for optimization and design of structures subject to complex loading (e.g., dynamic impact loads). The choice of the material model and the computational framework is important because it influences the accuracy of predictive results. In this study, we primarily focus on structural-scale modeling of ceramics under high-velocity ballistic impact by incorporating the user-defined Johnson-Holmquist-Beissel (JHB) material model within the framework of Smoothed Particle Hydrodynamics (SPH) in LS-DYNA modeling software. After ensuring that the implementation of the JHB material model was correct by comparing equivalent stress-pressure plots through a single element simulation test, we draw upon experimental results published in the literature to validate the model, where we focus on the damage patterns, cone size, residual mass, and residual velocity of the projectile. In addition, the effects of some numerical settings of SPH method through parametric studies were also investigated in this work, including particle spacing, artificial viscosity coefficient, numerical control, and contact treatment. The observations of parametric difference were then used to determine appropriate values for SPH model parameters of the ballistic impact problem. Comparing the results of the experiments and simulation, we observed a good agreement, and this indicates the present material modeling framework can realistically simulate the response of ceramic upon high-velocity impact, and SPH is well suited for impact problems. Overall, this study provides the guidance for development of future multi-scale numerical models and structural scale design of protection systems. This work was in collaboration with Defence Scientist Geneviève Toussaint of the Defence Research and Development Canada (DRDC) through NSERC CRD-DND project DNDPJ 531130-18.

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