Time-discontinuous Material Point Method for Transient Problems involving Discontinuities in Stress

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Abstract

Numerical predictions of the transient responses of structures to blast and/or impact loading conditions play an important role in modern engineering designs such as those for the explosive devices, the protection armors in military vehicles, and the impact protection units in automobiles. As one of the most efficient numerical methods, the material point method (MPM) [1] have been successfully applied to predict the hyper-velocity impact [2] and the dynamic responses of porous media [3] and are promising for the transient analysis of these structures subjected to blast and/or impact loading conditions. However, it should be noted that the transient problems involving the discontinuity or sharp gradient characteristics have still not been well handled with the existing MPM-based methods. Recently, based on the time-discontinuous Galerkin formulation [4], we proposed a time-discontinuous material point method (TDMPM) to better simulate these transient problems. In the TDMPM, the displacement and velocity fields in each time interval are interpolated by the corresponding values at the two time instants that enclose the time interval via the piecewise cubic and linear functions, respectively, and a novel computational framework for updating the grid displacements and velocities at discrete time instants is set up. The new formulations preserve the continuity of the displacement field at each time instant, while allow the velocity field at the corresponding time instant to be discontinuous. Thus the TDMPM can properly capture the discontinuous characteristics and suppress the spurious numerical oscillations. Numerical results show that the proposed method is efficient and accurate. This work was supported by the National Natural Science Foundation of China (11672062 and 11232003) and the Fundamental Research Funds for the Central Universities (DUT14YQ217).

Keywords: Material point method; Time-discontinuous formulation; Transient responses

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