Shear band evolution and post-failure simulation using an improved extended material point method

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An improved XMPM formulation is proposed to simulate the evolution of shear bands and post-failure behaviors with large deformations (e.g. landslide). The XMPM introduces a localization search algorithm based on the theory of bifurcation to predict the initiation and propagation of shear band. To deal with the dynamic frictional contact mechanism between the generated shear planes, a formulation of self-contact is integrated into the XMPM framework. In addition, a hybrid implicit-explicit description of discontinuity is considered by employing the level-set method and a point cloud approach to ensure the smoothness of the discontinuity surface during localization propagation. Several numerical examples have been investigated to assess the accuracy and demonstrate the capability of the proposed XMPM approach in simulating the shear band evolution of different engineering problems in both 2D and 3D. The proposed formulation is proven to exhibit minor sensitivity with respect to mesh refinements in predicting the shear-band path. Furthermore, a slope failure simulation is presented to demonstrate the accuracy and capability of the method in simulating real-scale problems in both 2D and 3D. The 3D simulation further emphasizes the potential of the XMPM in modeling complex problems experiencing localization, which eventually leads to large deformations post-failure behavior.

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