Hybrid Material Point and Finite Element Method to Model Runout of Tailings Dam Failure

The Material Point Method (MPM) offers a key advantage over other methods to model geohazards due to its capability to account for indefinite displacements without mesh complications. Geohazards such as landslides and dam failure can feature displacements on the order of kilometers, and an accurate prediction of these runout extents is important for geotechnical engineers to mitigate them. The Finite Element Method (FEM) and Finite Difference Method (FDM), currently two of the most common numerical methods for modeling geohazards, cannot account for such large displacements, so empirical predictions are often relied on for runout estimates. Thus, MPM presents an opportunity to obtain deterministic runout predictions for unique geohazard scenarios. However, MPM still lacks the precision of FEM in modeling complex geohazard initiation scenarios, such as seismically induced liquefaction. We present a hybrid FEM-MPM method which simulates the initiation of failure in FEM and then transfers the model into MPM to simulate the runout process and obtain an accurate prediction of its extent. To demonstrate this hybrid method, we simulate the failure of the Mochikoshi Tailings Dam, an earthen embankment retaining saturated mine waste which failed due to the combined effects of seismic loading and soil liquefaction during the 1978 Izu-Ohshima-Kinkai earthquake in Japan. Featuring a seismic initiation scenario and a runout of hundreds of meters, this dam failure is an optimal case study to recreate with our FEM-MPM hybrid method and demonstrate its capability to model complex geohazards from beginning to end with a single model.