Meshfree Simulation of Empty Room Closure and Collapse at the Waste Isolation Pilot Plant
(以無網格法模擬廢棄物隔離廠中腔室閉合及崩塌之過程)

Abstract

The disposal of nuclear wastes at the Waste Isolation Pilot Plant (WIPP) has drawn significant concerns about nuclear criticality. The waste containers are placed in an underground disposal room (a rock-salt repository), and the natural process of room closure is expected to compress them over hundreds of years. As the compaction process greatly influences nuclear assessments, it is essential to predict the rock fracking and roof falling process, room porosity/permeability, and final repository geometry. The numerical simulation plays a vital role in predicting the waste isolation process, and it also provides valuable information to the operation and design of rock salt repositories.

In this research, we first introduce a viscoplastic creep-damage model to capture the long-period behavior of rock-salt. In order to avoid the ineffectiveness of the conventional mesh-based numerical methods in solving large deformation and fragmentation problems, the meshfree reproducing kernel particle method (RKPM) is proposed to model rocks fracturing, separating, falling, piling, and compacting in the room closure process. Several numerical issues, such as damage localization, pressure oscillation, and low energy modes, are precluded by novel meshfree-based numerical techniques. The proposed framework has demonstrated its effectiveness in solving a series of numerical examples, including a rock compression problem, room closure simulation, and roof fall modeling. It is verified that the proposed meshfree formulation successfully simulated large rock deformations, fractures, and rubble pile rearrangement to produce qualitatively realistic results.

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