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Recent advances in FEMs and MPMs for disaster simulations

Kenjiro Terada*[1], Shuji Moriguchi[1], Yuya Yamaguchi[1], Shun Suzuki[2]

[1] Tohoku University, International Research Institute of Disaster Science, 468-1 Aza-aoba, Aramaki, Aoba-ku, Sendai 980-8572, JAPAN, tei@irides.tohoku.ac.jp and http://www.cae.civil.tohoku.ac.jp/official/terada-e.html.

[2] Tohoku University, Department of Civil and Environmental Engineering, 468-1 Aza-aoba, Aramaki, Aoba-ku, Sendai 980-8572, JAPAN.

The main thrust in this presentation is the exploration of co-rotational finite element methods (FEM) [1] and material point methods (MPM) [2] applicable for disaster simulations to predict possible hazards and risks we may face. For example, we are particularly concerned the failure phenomena involving the following consecutive stages:

- At the first stage: a structure deforms in response to dynamic or static excitations and displays cracks along prescribed discontinuities so that it would be separated into several blocks.
- At the second stage: several sets of blocks lose static equilibria and start to move dynamically.
- At the third stage: moving blocks collide each other with friction and some of them further break up due to the shock generated by the collision.

To simulate this three-stage failure process involving large deformation and rotations with dynamic frictional-contact behavior, we have developed an energy-conserving mid-point algorithm based on the co-rotational FEM. Also, another new solid-liquid coupled MPM [3] have been developed to predict a collapse process of ground structures such as slopes and embankments subjected to excess water content during a heavy rainfall, which involves a transition process from a soil structure to flowing mixture. The implementations of these separate numerical methods are verified by conducting some numerical tests with a simple structure containing a potential discontinuity. Also, several numerical examples are presented to demonstrate their capabilities and performances in simulating multi-stage failure phenomena in slope disasters.

REFERENCES

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