Solid-liquid coupled material point method for sediment disasters

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1. Research interests

A new solid-liquid coupled material point method (MPM) [1,2] is developed with the aim to simulate a large-scale sediment disasters caused by heavy rainfall, which involves a transition process from a solidus to liquidus behavior of saturated soil. The governing equations are formulated based on the two-phase mixture theory and discretized with two layers of Lagrangian material points, each of which possesses the information about the soil and water separately. The material behavior of the solid phase is represented by elasto-plastic model, whereas the water is assumed to be a Newtonean fluid. In order to improve the robustness and efficiency in comparison with the previous studies, we introduce new discretization method for the governing equations of mixture. For the time discretization, by applying the fractional step projection method [3], the water is assumed to be incompressible to realize high accuracy and low computational costs. For the spatial discretization, we employ B-spline basis functions [4], which are supposed to suppress numerical oscillations induced by material points crossing grid lines, without losing the advantage of MPM that is suitable for parallel computing thanks to the standard domain decomposition technique. Proposed method is applied to simulate a model experiment of wave collision to sandpile to demonstrate the capability of the proposed method in dealing with scouring and transportation of the soil caused by water flow.

Figure 1 shows the schematic views of the model experiment and the numerical model of the sandpile, which is generated by reference to its actual configuration measured by laser distance meter. Snapshots of the numerical results are shown in Fig. 2 along with actual appearance in the experiment. As can be seen from the figure, they are in good agreement. Specifically, some portions of sandpile are washed out by the water flow and is distributed in the downstream side like a long tail. These results indicate that proposed method is capable of representing the characteristic behavior of soil-water mixture.

2. Perspectives for collaboration

Possible collaborators in UW would be those who can provide some experimental data of saturated soil behavior since quantitative validation of proposed method is insufficient now. Also, we would like to conduct numerical simulations of actual sediment disasters occurred in US and/or Japan.

Acknowledgments:
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References:

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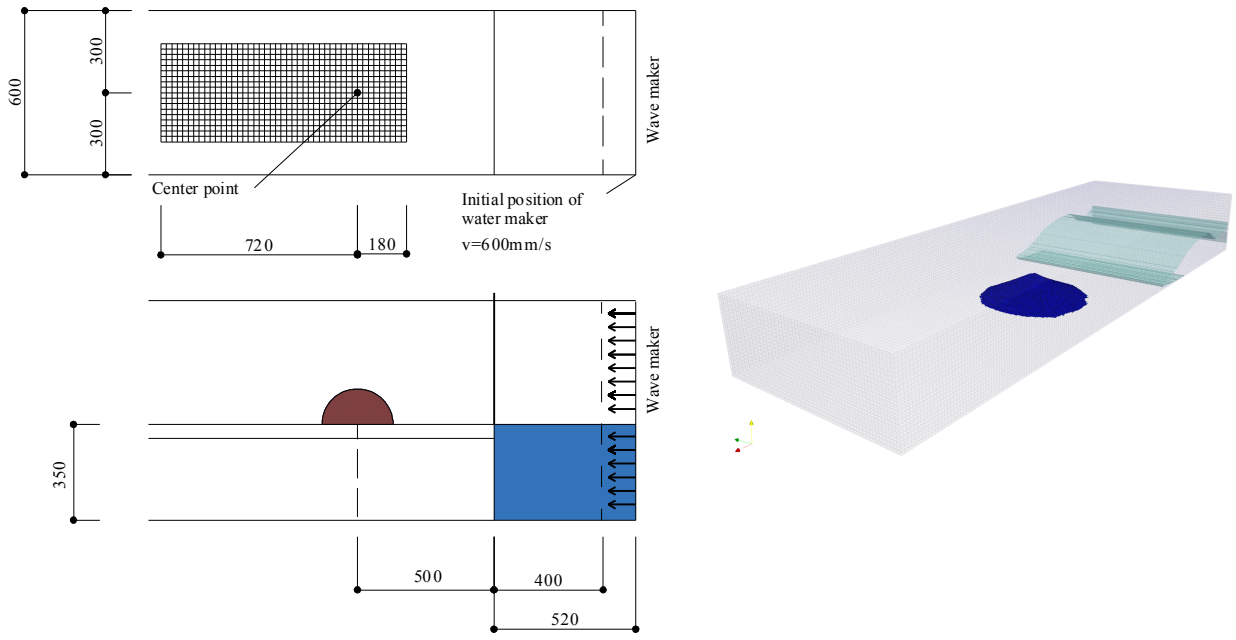

Fig. 1 Schematic views of model experiment of wave collision to sandpile (left) and numerical model (right)

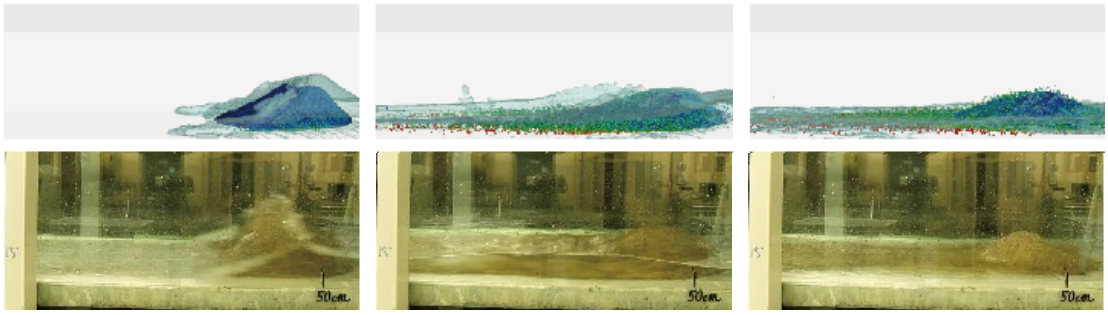

Fig. 2 Snapshots of numerical results: cumulative plastic strain (upper side) and photoglaphs taken during experiment (lower side)