Multi−physics tsunami disaster simulation for fluid-structure-soil interaction based on a particle method

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On March 11, 2011, the huge tsunami caused by the great east Japan earthquake devastated many infrastructures in pacific coast of north eastern Japan. Bridge washout disaster caused a traffic disorder and these collapse behaviors led to delay of recovery after the disaster, collapse of breakwaters may increase the disaster level in coastal area. After 2011 tsunami, disaster prevention and mitigation techniques are actively developing in coastal infrastructures and establishing prediction method for tsunami disaster is one of the severe issues toward the next millennium tsunami.
In our study, a multi−physics tsunami simulator based on the Smoothed Particle Hydrodynamics (SPH) Method has been developed. The SPH is widely used in field of fluid and solid dynamics, and a stabilized ISPH has been developing to treat the coupling behavior among fluid-structure-soil mechanics. A coupling method of ISPH method and DEM is utilized in our multi-physics simulations, and the coupling method is divided into two methods. One is the “Direct pressure model”. In general, a structure in fluid moves by receiving a pressure from fluid. In this method, the structure, which is modeled as a rigid body dynamics with particles, moves in same way. This coupling method requires that the diameter of fluid particles need to be much smaller than the structure size to calculate a fluid force acting on the structure surface accurately. Therefore, the analysis cost is high to analyze a large scale model such as a breakwater collapse with this method. Then, the other method “Interaction force model” is necessary to simulate fluid-soil interaction. In the interaction force model, a fluid particle can overlap with solid particles, and fluid pressure don’t acts on a solid particle. Instead of pressure, an interaction force acts on each particles, a resistance force on fluid and a drag force on solid. Furthermore, the diameter of fluid particle can be almost the same size with a solid particle. This method can reduce the analysis cost compared than “Direct pressure model”, therefore “Interaction force model” becomes efficient techniques in fluid-soil interaction simulations. The performance and efficiency of our developed multi−physics tsunami disaster simulation tool is given through a couple of verification and validation examples.

キーワード：粒子法、流体構造連成解析、水土連成解析、高粘性流体解析
Keywords: particle method, fluid-structure interaction, fluid-soil interaction, High viscus fluild simulation

