Numerical Analysis of Flooding using Explicit Moving Particle Simulation

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Abstract

Moving Particle Semi-implicit (MPS) method was developed for analyzing incompressible viscous flow with complex motion of free surfaces [1]. An fully explicit algorithm (EMPS, Explicit Moving Particle Simulation) was developed [2-4]. The sound speed is artificially reduced so that the Mach number is kept in 0.1 - 0.2. It was found that the same time step could be employed as that of the semi-implicit algorithm. Therefore, the computation time is much reduced in the EMPS method without solving simultaneous linear equations. In addition, the computation time of the EMPS method is linearly proportional to the total number of particles. Thus, the EMPS method is fitted to large scale problems of fluid dynamics with complex free surface motion.

Tsunami run-up and subsequent flooding in the building have been analyzed by the EMPS method [5, 6]. As an example, tsunami run-up on Fukushima Dai-ichi Nuclear Power Station by the Great East Japan Earthquake in 2011 is analyzed. Using the result of the above analysis, flooding in the turbine building of Unit #1 is evaluated. Seawater spreading in the turbine building was calculated and we can discuss the process of blackout due to the damage of power panels in the building. Effect of floating objects in tsunami run-up can be analyzed as a rigid body-fluid coupled problem using the EMPS method. Flooding caused by the break of a pipe or a water tank in the building is also important for the safety of nuclear power plants. This is called internal flooding. The EMPS is useful to analyze this type of accidents.

Flooding is also studied in ship engineering. When a break occurs on the ship surface below the draft line. Water enters into the ship. Dynamic behavior of the ship motion is analyzed by numerical analysis using the particle method. In automobile industry, the EMPS method is applied to numerical analysis of the waterway driving test.

Keywords: Particle Method, MPS, Fluid Dynamics, Free surface, Flooding.

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