SIMULATION OF CONTAINER DRIFT UNDER EXTREME HYDRODYNAMIC CONDITIONS

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INTRODUCTION

In Great East Japan Earthquake of 2011, debris entrained within the incoming tsunami waves was responsible for widespread infrastructure damage (Chock et al., 2011). The presence of debris within the inundating wave needs to be taken into consideration; however, few methodologies and tools exist to estimate debris hazards. Therefore, one option to evaluate the behavior of drifting debris is using numerical models. Currently, the particle method, which is a meshless analysis method, is expected to be utilized for analyzing the behavior of drifting objects (Goaseberg et al., 2017). However, the ability of models to properly capture the interaction between multiple drifting objects has not yet been verified. This study will be among the first to model drift behavior of multiple debris under tsunami-like conditions, using the DualSPHysics model suite.

METHODS

The physical experiments employed for the simulation were conducted in the Dam-break Wave Flume at the University of Ottawa, Canada (Stolle et al., 2019). Multiple 1/40-scale shipping containers were entrained and moved by a turbulent dam-break wave. Data on the containers'rotation, longitudinal and transverse displacement were measured in the experiment. DualSPHysics (Crespo et al.,2015), an open-source numerical fluid dynamics tool based on the particle SPH method was used to reproduce the experiments (Dominguez et al., 2021). Chrono (Tasora et al., 2016) was used to simulate drifting containers in the numerical wave flume (Figure 1). The drifting trajectory was validated with the results of the experiment (Hafen et al., 2021). Furthermore, several case studies were performed to analyze the influence of the initial gap ratio (1.0, 1.1, 1.2, and 1.4) between the debris on their trajectory.

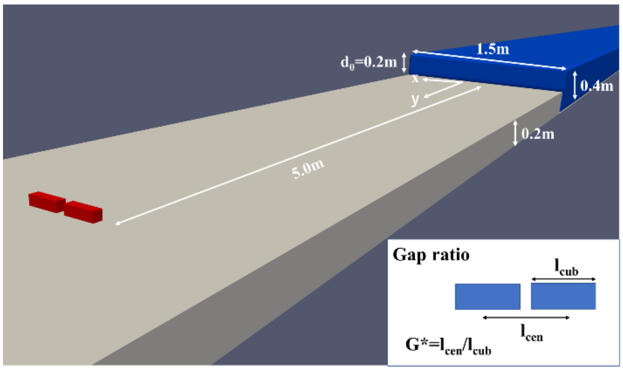

Figure 1 - Numerical model configuration and initial debris position layout.

RESULT

Figure 2 shows the drift trajectory of a container during simulated tsunami inundation in four cases. The lateral displacement of simulated floating containers was analyzed in the space. In all cases, the floating containers on each side gradually spread in the numerical simulations, which is consistent with the results of experiments (Figure 2). Comparison of the reproducibility at each gap size using RMSE showed that the accuracy between simulation and experiments was

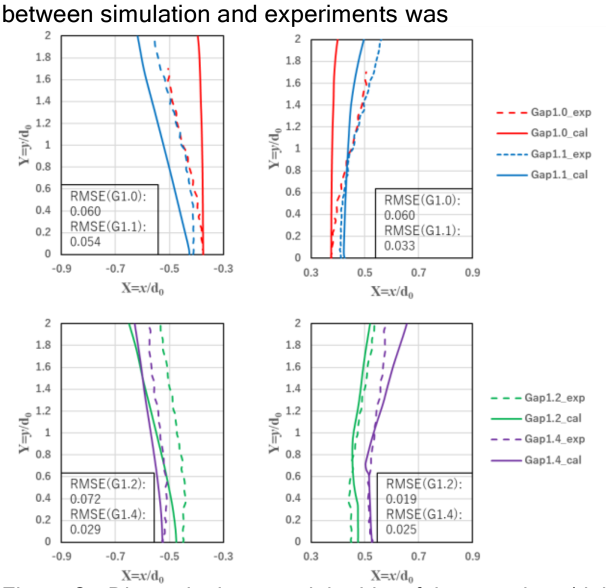

Figure 2 - Dimensionless spatial orbits of the container (right and left figures show that right and left initial position of containers). d_0 is an initial water height of 0.2 m.

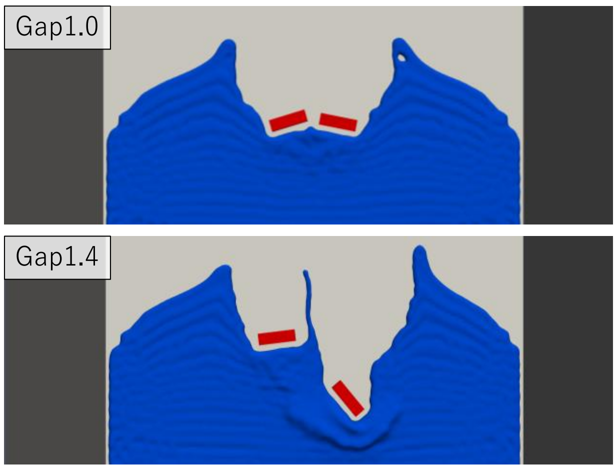

Figure 3 - Snapshot of the containers at simulation time of 3.1 (s). The upper and lower case show Gap1.0 and Gap1.4 case, respectively.

relatively low for small gaps (Gap1.0 case)and tended to improve with increasing gap size (Gap1.4 case). The result of round mean square errors (RMSE) for the Gap1.4 case is close to the values reported in the previous study which used one cuboid as debris (Ruffin et al., 2021). This is mainly because the water flow in between the containers was well reproduced in the case where a relatively larger gap size existed between the containers (Fig. 3).

CONCLUSION

This is one of the first studies of numerical simulations of multiple drifting containers under dam-break waves were performed using DualSPHysics. The drift trajectory of two side-by-side containers were well reproduced when compared with the hydrodynamic experiment. Additionally, it was found that the reproducibility of lateral displacement of containers is significantly affected by the surrounding fluid conditions reproduced in the numerical simulations such as intrusion of water between containers.

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