NUMERICAL STUDY ON MOVEMENT OF TSUNAMI BOULDER AND STORM BOULDER BY SPH METHOD

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INTRODUCTION

Smoothed Particle Hydrodynamic (SPH) method is a Lagrangian mesh-less method. The technique discretizes a continuum using a set of particles or material points, so it is known that SPH is useful to for dealing with large deformation problems that is difficult to handle with Euler method. Also, in coastal region, it has been reported that boulders made of coral limestone carried by tsunamis and super typhoons. These boulders are named tsunami boulders and storm boulders, and many researches have been conducted. Kiso et al. conducted the hydraulic model experiment using boulder models and evaluate the characteristics of boulder movement when tsunami and high wave act. This study aims to simulate the boulder movement measured in the experiment numerically by SPH method and discuss the difference of boulder movement characteristics between different wave types.

SET UP

This research uses DualSPHysics which is an open-source code. Navier-Stokes equation is discretized by set of particles or material points. The calculation is conducted by GPU or CPU and GPU enables us to simulate millions of particles. The collision between solid particles is calculated by Distinct Element Method. Also, dynamic boundary condition which is a default method in DualSPHysics is used to distinguish the fluid particles and solid particles. In this condition, solid particles satisfy the same equation as fluid particles, however they do not move according to an imposed motion function, such as piston movement and floating objects. When fluid particles approach solid particles, the density of the affected boundary particles increases, resulting in a pressure increase. This study uses symplectic time integration algorithm. Incident wave conditions are as follows: water depth 0.840 m, solitary wave height 0.150 m, significant wave height 0.295 m, and significant wave period 2.55 s. The shape of boulder is reproduced by 3D scanning data. Two sizes of boulders are used, 10C and 17C which maximum lengths are 10 cm and 17 cm, respectively.

MAJOR RESULTS

Figure 1 shows snapshots of boulder movement. It indicates that the direction of wave action when the boulder moves is different. Solitary wave acts on boulder before wave breaking whereas irregular waves act on boulder after breaking. Solitary wave overtops boulder and lifts the boulder, while irregular waves act horizontal direction. Fig.2 shows amount of movement was fairly reproduced in the numerical wave flume compared to physical model. Also, time series of overturning moment acting on boulders are shown in Fig.3. When solitary wave acts, moment acts continuously, while when irregular wave acts, moment acts instantaneously. It was confirmed that sometimes storm boulders did not move even large overturning moment acted. The results indicates that not only the magnitude of moment but also the wave action time is important for evaluate the boulder movement.

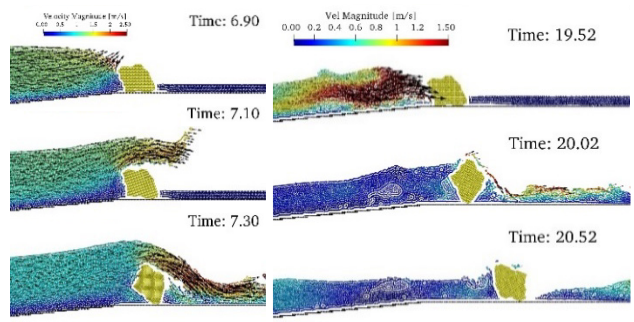
CONCLUSIONS

Numerical simulation by SPH method revealed the detail movement characteristics of tsunami and storm boulders which did not get by the experiment. The results indicated that differences of wave action direction and overturning moment affect the movement characteristics.

REFERENCES

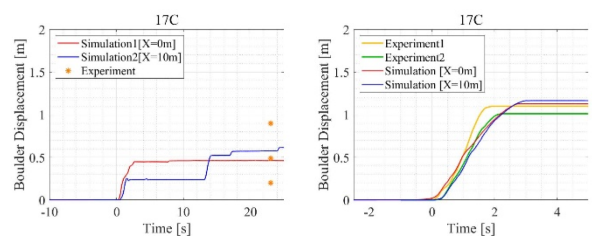
Crespo, A.J.C. et al.(2015): DualSPHysics: Open-source parallel CFD solver based on Smoothed Particle Hydrodynamics (SPH), Computer Physics Communications, 187, 204-216

Kiso, S. et al.(2018): Experimental Study on Transport Characteristics of Coastal Boulders by Tsunami and High Waves, Jour. of JSCE, Ser. B2 (Coastal Eng.), 74, 2, I_361-I_366.



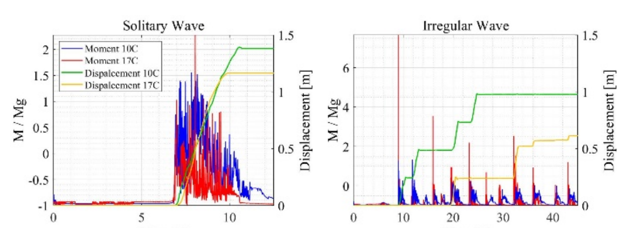
(a) Solitary wave (b) Irregular wave

Figure 1. Snapshots of boulder movement



(a) Solitary wave (b) Irregular wave

Figure 2. Comparison of boulder displacement between numerical simulation and experiment



(a) Solitary wave (b) Irregular wave

Figure 3. Relationship between boulder displacement and overturning moment