Bridges wash out simulation during tsunami by a stabilized ISPH method

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ABSTRACT

In 2011, huge Tsunami caused by the great east Japan earthquake devastated many infrastructures in pacific coast of north eastern Japan. Particularly, the damage of wash out of bridge girders caused a traffic disorder and these collapse behaviours lead to delay of recovery after the disaster. After 2011 tsunami, disaster prediction method for tsunami disaster is one of the severe issues toward the next millennium tsunami.

In this study, the bridge wash out accident is selected as a target issue, and we try to represent these accidents by using a numerical analysis. For this purpose, a stabilized ISPH[1], which is one of the modified versions of the SPH and can evaluate much smoother pressure distribution, has been developed in our research group.

The general momentum conservation law of the rigid body is solved numerically with the external forces including hydrodynamic forces as a fluid-rigid interaction formulation. The rigid body is discretized as particles at the beginning, and the forces of rigid body particles are calculated from the hydrodynamic and external forces. Meanwhile, the translational velocity $\boldsymbol{T}$ and angular velocity vector $\boldsymbol{\omega}$ are evaluated by using equation of motion. Finally, the velocity of each particle in the rigid body can be expressed as

$$\boldsymbol{v}^{n+1} = \boldsymbol{T} + \boldsymbol{\omega} \times \boldsymbol{r}_k \qquad (1)$$

where, $\boldsymbol{r}_k$ is the relative coordinate of a rigid particle to the centre. Note that accuracy of the rigid body motion is strongly dependent on the pressure calculation in the SPH. Our proposed stabilization and boundary treatment have an important role to calculate a good pressure distribution.

The result of bridge wash out simulation is shown in Figure 1. From this result, this fluid- rigid coupling algorithm can expressed the wash out behaviour. In the future work, the verification and validation of our simulation technique is necessary, before the simulation may apply to the design of bridge for huge Tsunami.

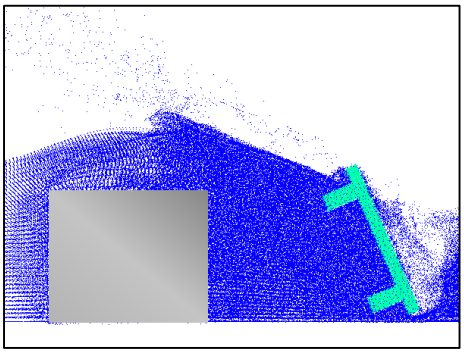

Figure 1. Snapshot of bridge wash out simulation

REFERENCES

[1] Asai M., Aly A.M., Sonoda Y., and Sakai. Y., "A Stabilized Incompressible SPH method by relaxing the Density invariance condition," Journal of Applied Mathematics, 2012, 24.doi:10.1155/2012/139583(2012).