Estimation of impact force of tsunami with debris based on surrogate modelling

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ABSTRACT

This study presents an estimation method of impact forces caused by tsunami containing debris with the use of a surrogate model constructed by a series of numerical simulations of fluid-rigid-body interaction problems in representative control volumes. The 3D finite/discrete element coupled method (FEM-DEM) is employed as an analysis scheme to consider the interaction between fluids and debris, whereas the transmission of forces at the interface between them is evaluated by using the finite cover method (FCM) [1] with unstructured meshes. For adequate quantitative evaluation, the surrogate model is represented by a response surface of the impact force on structures that is a scalar-valued function approximated with the simulation results calculated with different water heights and velocities as well as amounts of debris so as to be utilized in structural designs. Since the time-variation of the impact force of the fluid with rigid objects on a structure is obtained in each calculation, we also discuss how to determine the impact force as a unique value for a single set of numerical simulations. The uncertainty about the independent variables of the surrogate model is also considered. Specifically, we quantify the effect of the uncertainty of the fluid's height and velocity as well as the amounts of debris on the impact force by conducting Monte Carlo simulations with the constructed surrogate model. The numerical results are compared with those of the conventional evaluation form available, e.g., FEMA [2], which reflects the material properties and shapes of solid objects. It is then demonstrated that the proposed estimation method is applicable to risk assessment of structures subjected to impact forces by tsunami containing debris.

REFERENCES

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[2] FEMA, "Guidelines for Design of Structures for Vertical Evacuation from Tsunamis", Second Edition, *Applied Technology Council*, (2012)