PHYSICAL MODEL OF TSUNAMI-LOADS ON A SEASIDE BUILDING ARRAY

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INTRODUCTION

The devastating damage to buildings and infrastructure caused by the 2011 Tohoku-oki earthquake and tsunami highlighted the importance of evaluating tsunami impacts in areas at risk of tsunami inundation for disaster prevention and mitigation. Evaluation technologies have been vigorously researched and developed over the past decade. A wide variety of numerical models exist that can potentially be applied to evaluate tsunami impacts. Furthermore, several either theoretical or empirical models to evaluate tsunami impacts, such as evaluation models of debris impact force and tsunami wave pressure, have been proposed. To validate these numerical and evaluation models, both experimental and theoretical benchmark tests have been conducted (e.g., Horrillo et al., 2015). Most of these tests have been conducted to validate models of tsunami generation, propagation, and inundation. However, the number of benchmark tests to validate tsunami loads are limited, and especially, those for complex terrains are rare. In this study, as a benchmark test to validate modeling of tsunami inundation and wave pressure, hydraulic experiments of tsunami inundations were conducted over a seaside area model, in which building arrays were installed. The inundation depth, velocity, and pressure were numerically predicted for the condition of the benchmark test, and then compared with the measured data for validation.

BENCHMARK TEST

A set of hydraulic experiments were conducted to evaluate the tsunami inundation and wave pressure acting on buildings and tanks installed in a seaside area. CRIEPI's Large Wave Flume, which is 205 m long, 3.4 m wide, and 6.0 m deep, was used. A tsunami-like wave was generated by a piston-type wave generator offshore, which flowed over the seaside area. The seaside area was set up as an idealized coastal industrial site using models of rectangular-formed buildings and cylinder-formed tanks with a scale of 1/50 based on the Froude similarity law (Figure 1 (a)). Water levels and velocities at the offshore area were measured at nine points and two points, respectively, for each experiment. Separate experiments were conducted to measure pressure, inundation depth, and velocity of water in the seaside area, as measurements of the inundation depth and velocity can disturb the water flow because they are contact-type measurements. In the pressure experiment, pressures were measured at either six or eight heights along several vertical lines on buildings and tanks. The pressure at five lines were simultaneously measured using 32 pressure transducers. The experiments were repeated under the same tsunami conditions while the pressure measurement lines were changed. In the flow experiment, inundation depths were measured by wave gauges at 72 points. The velocity above the seaside area was also measured at 16 points. The experiments were conducted for three types of tsunami-like flow, among which its height and period are different.

VALIDATIONS

The pressure on buildings and tanks, inundation depth, and velocity in the seaside areas were predicted using two approaches. The first approach was to predict the inundation depth, velocity, and pressure directly using three-dimensional numerical simulations (Figure 1 (b)). The second approach was to predict the inundation depths and velocities using two-dimensional simulations, while pressures were predicted using tsunami-wave-pressure models proposed in early studies. The predicted results were compared with the data from the benchmark test, and the results demonstrated that either approaches can predict the measured data roughly well although the prediction accuracy depends on the approach and model parameters.

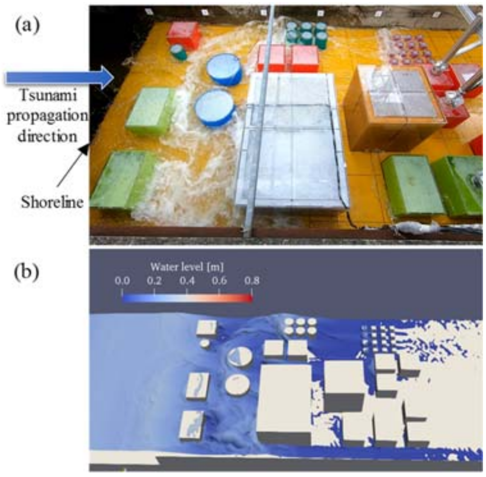

Figure 1 – (a) Image of the benchmark test, and (b) a snapshot of the water level predicted by the three-dimensional simulation.

REFERENCES

Horrillo, Grilli, Nicolsky, Roeber, Zhang (2015): Performance benchmarking tsunami models for NTHMP's inundation mapping activities. Pure and Applied Geophysics, Springer, vol. 172 (3-4), pp. 869-884.