LARGE-SCALE LABORATORY EXPERIMENTS AND NUMERICAL MODELING OF WAVE FORCE AND PRESSURE ACTING ON THE URBAN STRUCTURES

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INTRODUCTION

Low lying coastal communities are most vulnerable to the flooding which causes from sea-level rise (SLR), and extreme coastal flooding events such as hurricanes and tsunami. Notably, the high elevation of sea-levels due to SLR and local tidal conditions could accelerate the damages on the coastal communities. Hard coastal structures such as a submerged breakwater and seawall would consider minimizing the impacts of overland flows to the urban area from the extreme coastal events, but the effectiveness of those hard structures are significantly alter depending on the various waves and sea-level conditions.

LABORATORY EXPERIMENTS

For the research of inundation aspects and impact forces on coastal urban structures, three-dimensional laboratory experiments were conducted in the Large Wave Basin (48.8m long, 26.5m wide, and 2m deep) at Oregon State University to investigate horizontal wave force and the vertical variation of wave pressure of the simplified box-type urban structures. Three different experimental cases were taken into account as different countermeasure such as submerged breakwater only (SB), seawall only (SW) and submerged breakwater in accompanied with seawall (SBSW) using different sea-levels and wave conditions.

Six horizontal load cells were mounted on each structure in cross-shore direction, and a six-degree of freedom load cell was installed on the structure in the middle. Pressure transducers were mounted vertically in front of the building structure located in the most seaside. ADVs, wave gauges, and ultrasonic wave gauges are installed to measure flow velocities, water surface elevation, and inundation level, respectively. The wave conditions in the experiments included regular, random(TMA) and tsunami-like waves.

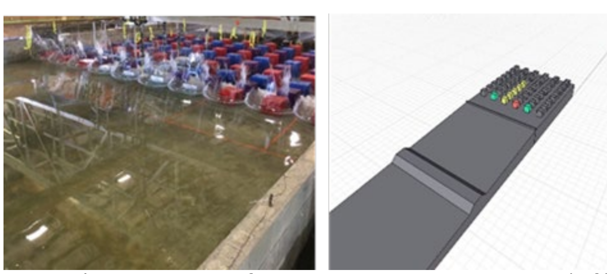

Figure 1 - A snapshot of wave impact on the structure (left) and computational domain for numerical simulation (right)

NUMERICAL MODELING

The olaFlow based on two-phase Reynolds Averaged Navier-Stokes equation was verified by comparing the results with the experimental data. olaFlow uses the finite volume method and VOF method (Kissling et al.,2010), and the dominant mathematical expression is the VARANS equations, which includes the equations of continuity and momentum conservation. At first, the model was tested to simulate the experimental results of the wave loads on the structure in tsunami-like wave cases.

After the verification, the model simulated the wave force and pressure acting on the structure under the various wave and sea-level conditions to understand the combined effects to the overland structures according to the different countermeasures such as SB, SW, and SBSW. The results of experimental and numerical model results were used to find an empirical formula of the wave loads and to estimate fragility curves of the urban structure in the coastal city.

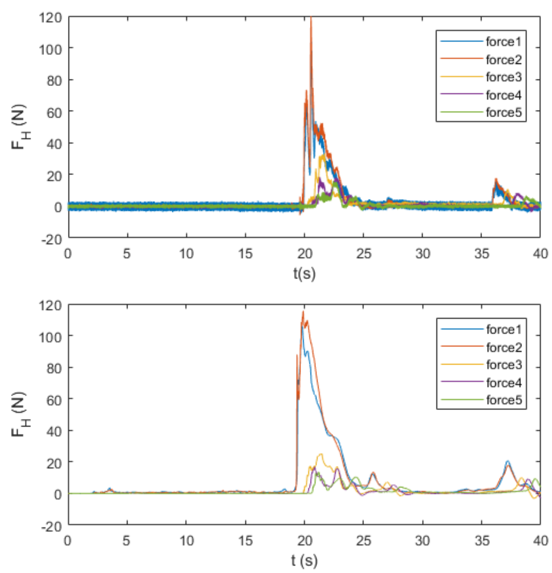

Figure 2 - Wave force on the structures: experimental results (top); numerical model results (bottom).

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