EXPERIMENTAL DATA AND NUMERICAL SIMULATION OF WAVE LOADING AND ITS REDUCTION ON SHELTERED BUILDINGS

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INTRODUCTION

Wave loading from inundation events like storms and tsunamis can cause severe structural damage to buildings (Xian et al., 2015); therefore, it is important to predict wave loading as accurately as possible. One uncertainty in estimating wave loads during inundation events is the possible reduction of loads by sheltering from other buildings. Understanding and quantifying this effect could reduce overestimated loads in sheltered buildings and avoid overconservative structural design. This work aims to quantify the reduction of wave loads in sheltered buildings through the analysis of experimental data and numerical simulations.

EXPERIMENTAL DATA

Laboratory tests were performed in the Directional Wave Basin in the O.H. Hinsdale Wave Research Laboratory at Oregon State University. As shown in Figure 1, a regular array of 10 x 10 = 100 buildings was placed in a flat bed, where wave loads were recorded with load cells for one building in each of the first five rows. This configuration and instrumentation allowed us to measure the wave loading in the first five rows and therefore the reduction of the loads as more shelter is provided. Single and random waves were considered in both dry and inundated flat bed conditions. Waves with a constant current condition were also considered.

METHODOLOGY

Maximum loads were obtained from the load cells and reduction factors (RF_i) for each row were computed according to $RF_i = \max F_i / \max F_1$, where $\max F_i$ is the maximum load recorded in the i^{th} row. Note that for the first exposed row, this factor is always $RF_1 = 1$. Given the constraints in laboratory experiments, numerical simulations using olaFlow, a Reynolds-Average Navier-Stokes (RANS) solver based in OpenFOAM (Higuera et al., 2015), were conducted to extend the number of cases, to easily change the geometry, and to add more virtual load cells, allowing us to obtain the wave loads in the buildings of all 10 rows.

RESULTS AND DISCUSSION

As shown in Figure 2, wave loading reduction driven by solitary waves on a dry bed increases as more shelter is provided by other structures. Significant shelter granted by the structures in the front was observed. The maximum wave load reduction factor is around ~ 0.3 in the second row of structures and becomes ~ 0.05 by the fifth row. Reduction factors obtained from the numerical model show a good agreement with the experimental data. The loads obtained with the numerical model keep decreasing as buildings become more sheltered. In the last row there is almost a complete reduction of the maximum wave load, where $RF_{10} = 0.015$. Given the magnitude of the reduction of the wave loads obtained, this work motivates and proposes a challenge in the methods of estimating wave loading when sheltering exists.

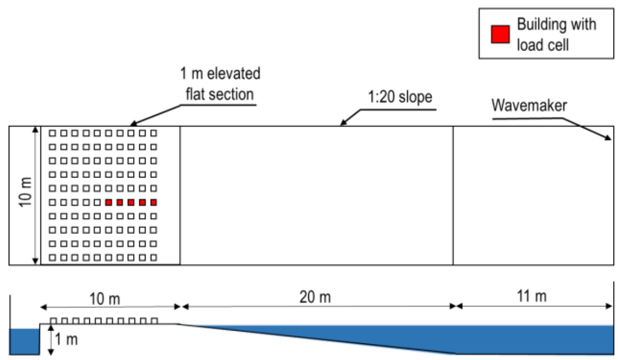

Figure 1 - Schematic representation of the experimental setup. Top: Plan view. Bottom: Elevated view.

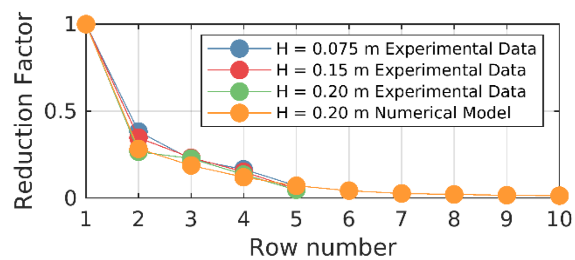

Figure 2 - Load reduction factors obtained from different solitary waves for both experimental and numerical results. Dry Bed condition. SWL = 0.98 m

REFERENCES

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