WAVE RUNUP ON AN ARRAY OF STRUCTURES DUE TO A SOLITARY WAVE INTERACTING WITH STEADY CURRENTS

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ABSTRACT
The present study investigates the runup patterns formed during the interactions of a solitary wave with an array of idealized structures in the presence of following and opposing steady current flows.

INTRODUCTION
The attempts to quantify the dynamics of wave - current interactions are primarily focused on the interactions between short (regular/irregular) waves and currents. A limited number of studies, however, deal with the interactions of solitary waves and currents (Zhang et al., 2014). Yet, very few studies consider interactions of such complex flows with a group of structures. This study presents, for the first time, experimental and high-fidelity numerical investigations of the interactions between a solitary wave and an array of structures on a berm beach (Figure 1) in the presence of steady following/opposing currents.

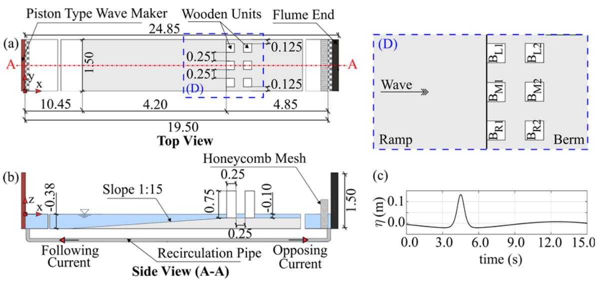

Figure 1 - Physical model setup: (a) plan view; (b) side view-section A-A; (c) wave signal generated by the paddle. All dimensions are in meters (Figure not to scale).

A series of experiments were performed at Coastal and Hydraulic Engineering Research Laboratory (CHERL) of Stony Brook University. A solitary wave of 0.1 m high was considered to interact with an array of idealized buildings on a beach berm. The wave was generated in the flume in the absence and presence of steady currents. Two different steady current velocities, one weaker and the other stronger, were generated using the flume flow recirculation system. The flow characteristics were measured and used to validate the model results generated using the open source solver, olaFlow, developed within the OpenFOAM framework (Higuera et al., 2013). olaFlow solves two-phase flow equations for water and air, and the interface of the two phases is resolved using the Volume of Fluid (VOF) method suggested by Hirt and Nichols (1981). Furthermore, large-eddy simulation (LES) is employed to resolve the local hydrodynamics formed during wave-current and structure interactions.

FINDINGS
The following currents shift wave breaking further landward, increasing the extent of inundation, whereas under the effect of the opposing currents, the wave breaks seaside of the building array. In the absence of a current, a plunging breaker occurs on the berm generating jet flows through the gaps between two adjacent elements. The opposing currents change the breaker type such that collapsing and spilling breaker are observed under the effect of weak and strong opposing currents, respectively. As a result, the runup patterns significantly differ for the different flow conditions. Figure 2 depicts the difference in the maximum runup patterns on the buildings in the front row. For the opposing current cases, the collision of the wave with the buildings in the front row is violent as the opposing currents lead to the wave breaking on the slope or on the berm. The noticeable turbulent region causes a complicated and slightly asymmetric runup pattern.

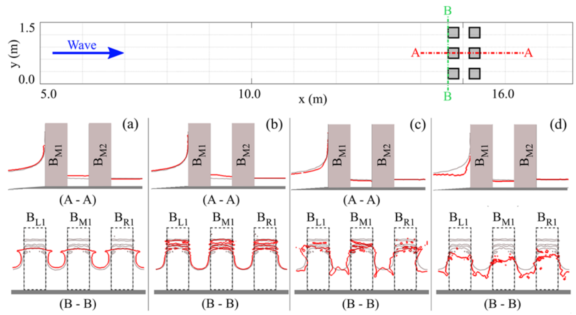

Figure 2 - Comparison of the predicted maximum wave runup on the first row of structures at sections (A-A) and (B-B). The gray and red lines represent the maximum wave runup in the absence and presence of currents, respectively. (a) wave+stronger following current; (b) wave+weaker following current; (c) wave+weaker opposing current; (d) wave+stronger opposing current.

CONCLUDING REMARKS
The currents control the breaking type and location on the berm beach. Hence, the wave runup heights on the buildings significantly vary under various flow conditions.

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