REVISITING WAVE PROPAGATION UNDER AIR FLOW IN COASTAL AREAS

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INTRODUCTION

The interaction between ocean waves and winds can be separated into two main analyses. A first interaction considers the wind as the primary wave generator. The mechanism through which wind exerts stresses to the water surface that combined with the gravity forces produce the surface oscillatory flow known as waves, is relatively well documented theoretically (Blennerhassett 1980), experimentally (Plate et al. 1969) and numerically (Liu et al. 2016).

On the other hand, as waves travel to the coast, winds stop being the generating force and turn into an energy source travelling along with the waves. In places close to the shore, winds can be directed with or against the wave propagation. It is straightforward that wave properties close to the shore are modified under different wind conditions (Xie 2017). Numerical and experimental studies on wave-wind interaction near the coast and in presence of obstacles exist but are still scarce (Medina 2001).

The present research is an experimental study of the perturbation produced by an air flow over waves in shallow waters and interacting with sloped obstacles. Well-known phenomena such as wave braking, steepening and run-up are revisited under wave-wind conditions.

MATERIALS AND METHODS

The research begins proposing a dimensional analysis focused on determining the most adequate non-dimensional numbers that may give proper Cartesian plans in which the studied phenomena may be plotted and characterized. Pi-Buckingham theorem was used to develop the analysis considering together variables related to waves and wind.

The laboratory tests were conducted at the 20 x 0.4 x 0.5 m wave flume of the Engineering Institute of the National Autonomous University of Mexico. The wave flume is equipped with a piston-type wave generator that features an active wave absorber. With this equipment waves were mechanically generated. On top of the flume a wind tunnel has been placed which can produce wind in either flume direction. A sketch of the facility is presented in Figure 1.

RESULTS

A first approach consisted in generating regular waves over a horizontal bottom and recording the perturbation produced by the air flow. With wind in the wave propagation direction, as expected, the energy increase resulted in a phase shift between the waves with and without air flow (see Figure2), together with an increase in the water surface roughness. The effects of the former are mainly an augmented wave celerity which turns into greater run-up and enhances energy dissipation due to wave braking. In turn, the effects of the latter are still to be analyzed.

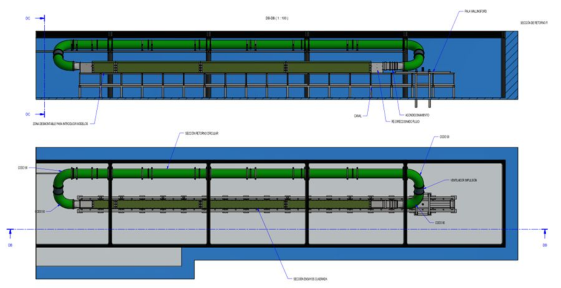

Figure 1 - Sketch of the wave-wind flume at the National Autonomous University of Mexico

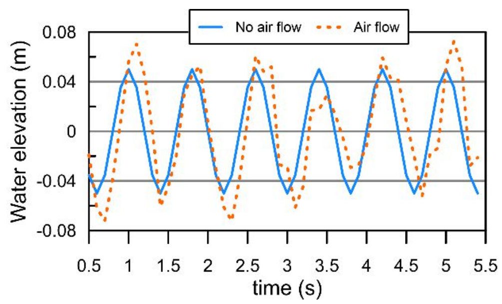

Figure 2 - Example of time series of water elevation for regular waves with and without air flow over a horizontal bottom.

CONCLUSIONS

A set of experiments on air flow over mechanically generated waves was conducted.

It was seen that the perturbations produced by wind on propagating waves can be significant enough to impact coastal structures design.

The wave energy distribution between reflection, transmission and dissipation can be altered by wind and it also depends on the wind direction.

The performed dimensional analysis let introduce non-dimensional numbers for the representation of the wave-wind-obstacle interaction phenomena.

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