PHYSICAL MODELLING OF BICHROMATIC WAVE PROPAGATION AND WAVE BREAKING IN A WAVE FLUME

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Paper topic: Laboratory and field observations and techniques

1. Introduction

The knowledge of the wave transformation and the wave breaking characteristics near the coastline is essential for the nearshore hydrodynamics and the design of coastal structures. Physical models and laboratory experiments are important tools of the research methodology for acquiring a better knowledge and characterization of these phenomena. The validation of the numerical models depends greatly on accurate and reliable experimental data.

Following this reasoning, a wide range of wave flume tests was performed at the National Laboratory for Civil Engineering (LNEC) to study the wave transformation and breaking considering different incident wave conditions.

Okamoto et al. (2010), Endres et al. (2011) and Neves et al. (2011, 2012) performed a set of experimental tests for incident regular wave conditions originating wave breaking, considering different bottom slopes. Conde at al. (2012) followed the methodology of these previous works, considering incident regular waves without wave breaking. The work presented in this paper follows the methodology of these previous studies, considering incident bichromatic waves with wave breaking.

2. Experiments

The experimental tests were performed in the wave flume represented in Fig. 1. This regular wave flume was designed with a reduction of width to improve its hydraulic behaviour, by preventing unwanted transversal waves, and, at the same time, to enable an increase of the regular wave heights (due to shoaling at the 1/11 bottom slope) produced by the limited capabilities of the original wave paddle. Nowadays, the flume is equipped with a piston-type irregular wave-maker system controlled by an A/D converter and a personal computer. This wave-maker can generate regular or irregular waves. A 10m long 1/22 slope beach profile, followed by a 10m horizontal zone were constructed. This bottom was made out of concrete so there is no permeability. At the end of the flume there is a 1/20 slope concrete bottom followed by a 1/2 slope gravel beach. Porous blankets (horsehair sheets) were installed over the 1/20 slope to reduce the reflected wave energy.

Experiments were made in three main phases, corresponding to different wave conditions: a) Regular waves resulting from the combination of four wave periods (T=1.1, 1.5, 2.0, and 2.5s) and six wave heights (H=0.08, 0.10, 0.12, 0.14, 0.16, and 0.18m); b) Bichromatic waves resulting from a combination of two of the previous regular waves considering a certain wave height, i.e. T=1.1 and 1.5s and H=0.06 and 0.08m; c) Irregular waves (JONSWAP spectrum) with Ts=1.5s and three different wave heights (Hs=0.12, 0.14, and 0.16m), Ts=2.0s and Hs=0.12m, and Ts=2.5s and Hs=0.12m.

For the selected wave conditions, two different water depths in the lee part of the bar (Fig. 1) were considered, d=0.1 and 0.3m, in order to have wave breaking and non-breaking conditions.

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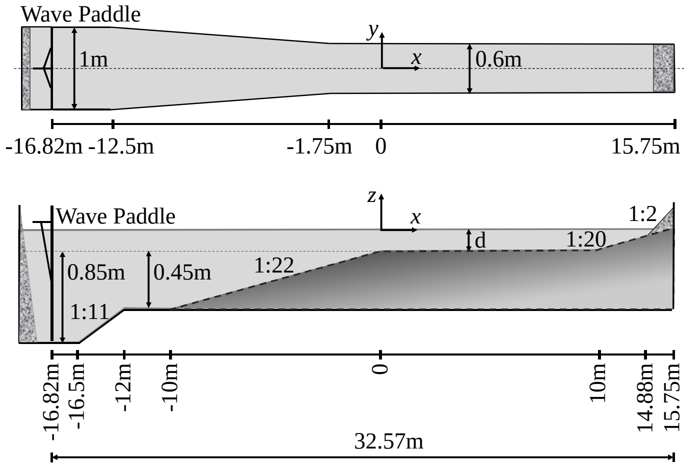

Figure 1. Wave flume’s plan and longitudinal-section views.

This paper only presents results for the bichromatic wave resulting from a combination of two regular waves considering a certain wave height, i.e. T=1.1 and 1.5s and H=0.08m for a 0.1m water depth, corresponding to wave breaking condition.

The total set of experiments was divided in three phases: a) Free surface elevation measurements along the flume with an 8 gauge mobile structure; b) Particle velocity measurements along the flume at the middle of the water column, using an Acoustic Doppler Velocimeter (ADV) probe; c) Vertical profiles of longitudinal velocity component at selected sections along the flume using the same ADV probe. Both free surface elevations and particle velocity measurements were made from x=-10m to x=7m, with 1m spacing. Velocity profiles were obtained at x= -10m, -5 m and -1m. Different types of data analysis were considered: a) Time and spectral analysis of the free surface elevations along the flume; b) Time analysis of the particle velocity measurements along the flume at the middle of the water column. Moreover, these results allowed the calculation of the particle velocities main characteristics and the two-dimensional distributions of velocity components in the xy, xz and yz planes; c) Time analysis of the vertical profiles of longitudinal velocity.
These analyses contributes for a better understanding of the wave breaking process and especially of the end part of this process and constitutes a set of data for the numerical modelling validation.

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