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METHODOLOGY OF THE EXPERIMENTAL TESTING OF AN OSCILLATING WATER COLUMN DEVICE IN A WAVE BASIN

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KEYWORDS

Spectral wave basin, oscillating water column device, wave energy, regular waves, random waves.

INTRODUCTION

Model scale testing in wave basins is critical in the development and evaluation of wave energy converters. It is the most reliable source of knowledge about wave energy converter (WEC) behavior in various sea conditions and it can provide modelling services in terms of setup and physical dimensions, while delivering a more realistic and accurate evaluation of physical model performance. In this work, we briefly describe the methodology followed during the experimental campaign of a land-based Oscillating Water Column (OWC) device evaluated on the spectral wave basin of the Autonomous University of Campeche. The tested OWC model is geometrically equivalent to a single chamber of the Mutriku Wave Energy Plant (MWEP). The purpose of this research was to investigate the influence of wave propagation conditions on the hydrodynamic performance of a fixed OWC device.

Materials and Methods

Test facility

The experimental campaign was conducted in the 15-meter-long, 9-meter-wide, and 0.8-meter-deep spectral wave basin of the EPOMEX Institute at Autonomous University of Campeche in Mexico. The wave basin is equipped with a linear snake wavemaker with eighteen piston paddles 50 cm wide each and an active absorption system (AwaSys). An artificial beach made of gravel at the other end of the basin acts as a passive wave absorber. The spectral wave basin showing the position of seven wave gauges and the OWC model tested are shown in Fig. 1.

Figure 1. Experimental set-up.

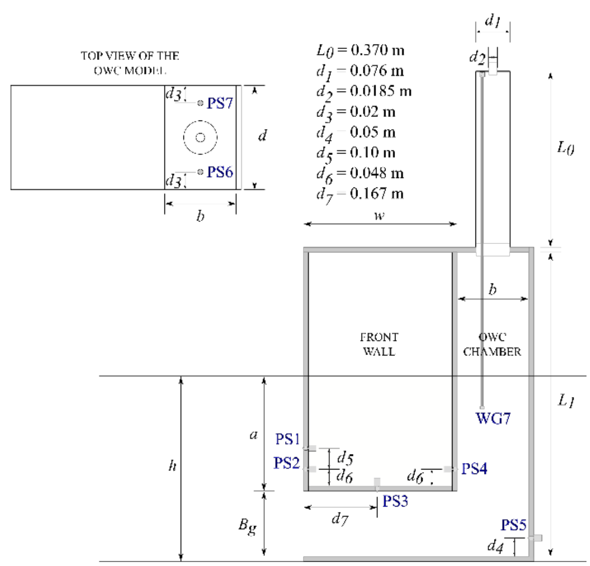

Figure 2. Vertical cross section and dimensional details of the OWC model.

Test model

For modelling the OWC chamber, a line scale of 1:20 was determined using the Froude similarity law. The OWC model was cut with a laser system from acrylic sheets with a thickness of 12 mm. Figure 2 and Table 1 show the dimensional details of the OWC model. The scaled OWC model in Fig. 3 corresponds to a single OWC chamber of the MWEP (Medina Rodríguez, A.A., et al. 2022).

Table 1. Geometric parameters of the OWC model.

Parameter	Value
Model length (b)	0.155 m
Model width (d)	0.255 m
Model height (L_1)	0.655 m
Model front wall thickness (w)	0.333 m
Gap length (B_g)	0.128 m

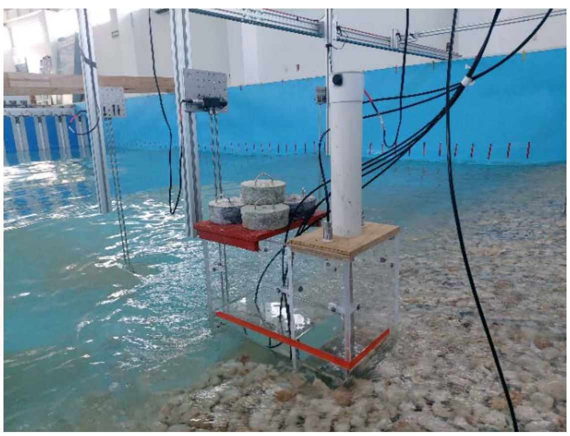

Figure 3. The experimental set-up of the land based OWC.

The scale ratio was determined by the size of the experimental facilities as well as the wave conditions under consideration and wave generation capability. Froude's similarity was used because it allows the model and full scale to represent a geometrical analogous OWC system.

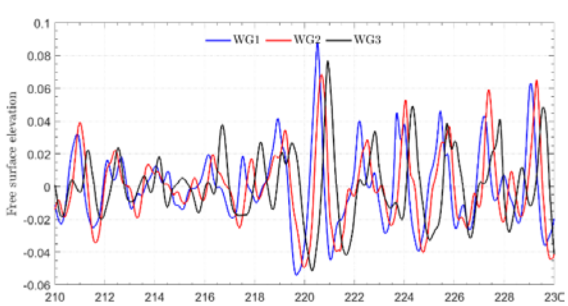

Figure 4. Time series measured by the selected wave gauges.

Instrumentation

To record water-free surface elevations, seven resistance-type wave gauges (0.01-0.70 m VTI, WG-1CH-E, Spain) were installed within the spectral wave basin. Six of these gauges were located along the centreline of the wave basin in front of the OWC model, and the remaining one inside the scaled OWC model, as shown in Figs. 2 and 3. The least square methodology is used to explore a method that uses an arbitrary number of wave probes. However, only three of them are chosen for spectra estimation and reflection analysis, Fig. 4. The approach is based on the principles of appropriately selecting a set of wave probes that can decrease labour in relocating wave probes when the test conditions use numerous wavelengths (Yuanzhe, Z. 2018).

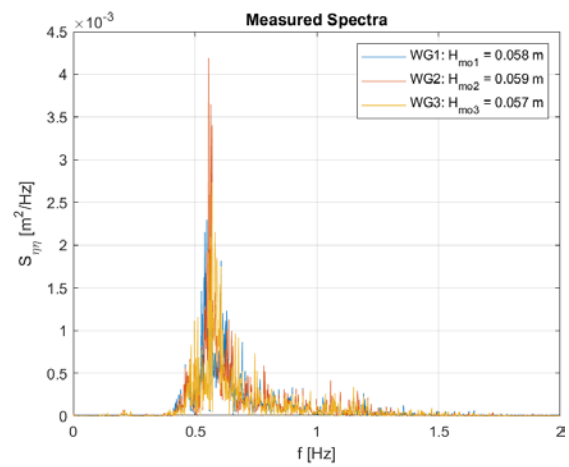

Figure 5. Measured spectra by the three selected sensors (T_p=1.74 s, H=0.1 m and h=0.4 m).

Two pressure gauge sensors (0-0.3 bar Acculevel, Keller, Virginia, USA) were placed inside the chamber at the top to measure the differential air pressure, Fig. 2. The sampling frequency of all these sensors was 100 Hz. The measurements were analysed inside the steady-state region of the signal.

Data Analysis

The least squares approach is used in reflection analysis to minimise the square errors between the spectra of observed and estimated surface elevations, Figs. 5 and 6 (Mansard, E., et al., 1980).

Conclusions

The hydrodynamic performance of a land-based OWC-WEC is investigated in this study through a series of experimental tests. The research was conducted to investigate the effect of wave propagation conditions on hydrodynamic performance. It is intended that this work would inspire additional research into the performance of land based OWC devices, as well as provide useful information for the successful extraction of ocean wave energy.

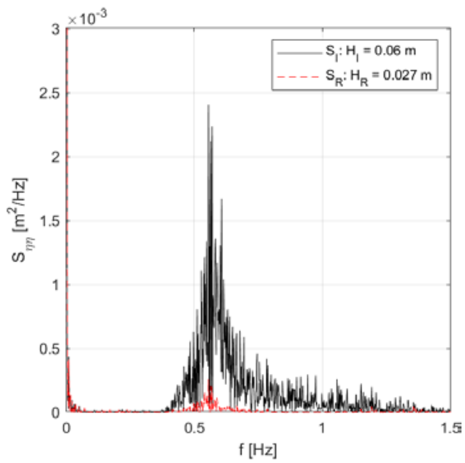

Figure 6. Separation of incident and reflected spectra, S_I and S_R, respectively.

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