2D PHYSICAL MODELLING OF WAVE-INDUCED FORCES AND OVERTOPPING ON VERTICAL CAISSONS WITH RETREATED CROWN WALL

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INTRODUCTION

Composite vertical breakwaters are monolithic coastal structures commonly employed for safeguarding harbor basins, particularly in deepwater microtidal conditions. Their design currently relies on Goda's formulae (Goda, 2010) or the probabilistic design tools (PROVERBS) proposed by Oumeraci et al. (2001). The overtopping performance of these structures can be predicted using tools outlined in the EurOtop Manual 2018. Due to the size of these structures, optimizing and enhancing their hydraulic performances, such as reducing wave loads and overtopping, can result in significant economic savings. Typically, designers attempt small geometric changes without altering the primary geometrical dimensions. To achieve this objective, several technical solutions are available. One of them consists in placing the cast-in-situ concrete crown wall at a retreated position relative to the front caisson face. It is assumed that the recession of the crown wall, for geometric reasons, induces a time lag between the loads acting on the caisson trunk and the crown wall. Additionally, this retreat could alter the pulsating nature of the loads, introducing turbulent dissipations, consequently varying the reflection coefficient and modifying wave overtopping. To the best of the authors' knowledge, literature lacks guidelines to consider the effects of crown wall retreat concerning wave actions and the hydraulic performance of the structure. Recently, Romano & Bellotti (2023) provided initial experimental insights into the increase/reduction of wave loads on deepwater vertical breakwaters with retreated crown walls. The paper deals with a 2D physical model study of wave-induced forces on a composite vertical breakwater, where the position of the crown wall has been varied during the tests. This research aims to enhance understanding of the physical phenomena related to wave-structure interaction in composite vertical breakwaters with retreated crown walls, expanding the work of Romano & Bellotti (2023). To this end, a parametric study has been carried out through 2D small-scale physical model tests in Roma Tre University's wave flume (9.00 m long, 0.27 m wide, and 0.50 m high), equipped with active wave absorption. The objective was to study the increase or reduction in both wave loads and wave overtopping as a function of the position of the crown wall under non-breaking wave conditions.

Various structural configurations of a generic caisson were investigated, using numerous pressure sensors (10 on the lower caisson, 4 on the crown wall) to measure wave pressures. See sensor's position in Figure 1, as well as geometrical notations. A tank with a chute was placed behind the structure to collect and measure wave overtopping, and resistive wave gauges in the channel measured free surface elevation and allowed a reflection analysis. In the initial phase, only regular sea states were used to explore a wide range of parameters (Table 1). The height of the wall was kept constant.

Table 1 Range of tested parameters

dimensionless parameter	min. value	max. value
G_c/L	0.000	0.196
R_c/H	0.518	2.805
H/h	0.090	0.373
H/L	0.008	0.121
h/h_b	3.200	6.000

By varying geometric dimensions and wave parameters, a total of **1932** tests have been conducted so far, each with a duration of 115 seconds.

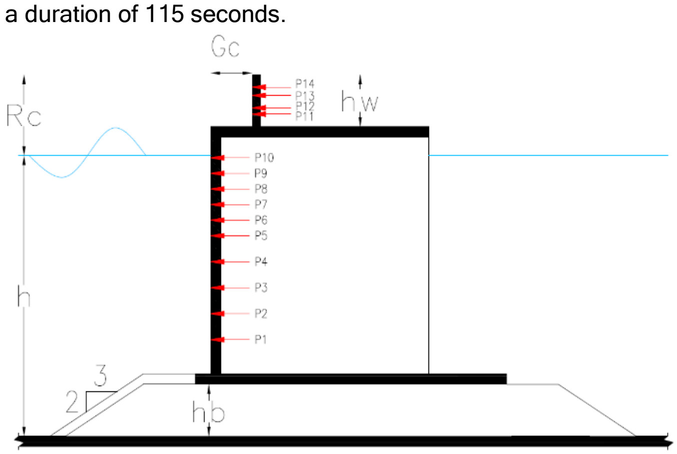

Figure 1 schematic representation of one of the physical models tested in the wave flume.

RESULTS

The analysis of the experimental data will include force and moment signals; pressures diagrams (an example is shown in Figure 2); reflection coefficients and wave overtopping as a function of the wall position, G_c. Ongoing analysis of the data collected during the experimental campaign suggests that the first experimental evidence aligns with and expands upon the findings of Romano and Bellotti (2023). As a general result, the experimental findings indicate that, for the tested setups, the global forces and moments influencing the caisson undergo notable variations based on the wall's position. Specifically, it seems that the global forces on the structure tend to decrease as the wall retreats increase. However, there are certain risky instances where the structure encounters loads equal to or greater than those observed in the flushed wall (G_c=0 m) configuration.

Further tests are planned with random waves and at a larger scale. These insights are expected to contribute valuable information for design guidelines or recommendations for this technical solution.

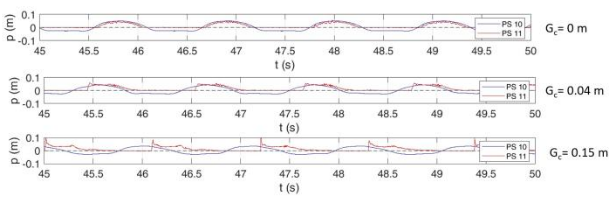

Figure 2 Pressure signals measured on the uppermost pressure sensor of the trunk P10 and the lowermost of the wall P11 under the same sea state for various retreats of the crown wall (G_c)

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