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PARAMETRIC ANALYSIS OF WAVE-INDUCED FORCES AND OVERTOPPING ON COMPOSITE VERTICAL BREAKWATERS WITH RETREATED CROWN WALL

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1 INTRODUCTION

Composite vertical breakwaters are monolithic structures often used to protect port basins, especially in deep-water conditions. At present, the design of these structures is mainly based on Goda's formulae (Goda, 2010) or on the probabilistic design tools (PROVERBS) proposed by Oumeraci et al. (2001), while their hydraulic performance in terms of overtopping can be predicted by using the tools described in the EurOtop Manual (EurOtop Manual, 2018).

Due to the size of these structures, the optimization and the improvement of the hydraulic performances (e.g. reduction of wave loads, wave overtopping, etc.) of these breakwaters can lead to significant economic saving. Typically, designers try to make small geometric changes without modifying the main geometrical dimensions of these structures. One of these technical solutions consists in placing the cast-in-situ concrete crown wall at a retreated position with respect to the front caisson face. It is assumed that the retreat of the crown wall, for geometric reasons, induces a time lag between the loads acting on the lower front external seawall face and on the crown wall of the caisson; furthermore, this could introduce a change in the pulsating nature of the loads, introducing also turbulent dissipations, consequently reducing the reflection coefficient and modifying the wave overtopping. To the best authors' knowledge, in the literature there is a lack of guidelines to consider the effects of crown wall retreat in terms of wave actions and hydraulic performance of the structure. Recently, Romano & Bellotti (2023), based on physical model tests, provided a first experimental insight on the increase/reduction of the wave loads acting on deep water vertical breakwaters with retreated crown wall.

The paper presents a 2D experimental physical model study of wave induced forces on a composite vertical breakwater, where the crown wave wall is variably retreated with respect to the front face of the caisson. This research aims at improving the knowledge on the physical phenomena related to wave-structure interaction of composite vertical breakwaters with retreated crown walls, by also expanding the work of Romano & Bellotti (2023). Thus, a parametric study was conducted through 2D small-scale physical model tests. The experiments were carried out in Roma Tre University's small wave flume (9.00 m long, 0.27 m wide and 0.50 m high) equipped with active wave absorption with the aim of studying the increase or reduction in terms of wave loads and wave overtopping as a function of the positions of the crown wall. Different structural configurations under non-breaking wave conditions have been investigated. A large number of pressure sensors has been used (10 on the lower wall, 4 on the crown wall) to measure the wave pressure acting on an ideal composite vertical breakwater; a tank with a chute was placed behind the structure to collect and measure wave overtopping, and a series of resistive wave gauges were installed in the channel to measure the free surface elevation and perform the reflection analysis. In this first phase of the experiments, only regular sea-states were used to explore a wide range of parameters. By varying the geometric dimensions (e.g., water depth, length of the promenade, berm height, wall height) and wave parameters, a total of 1396 test cases were carried out so far. Figure 1 shows a series of snapshots describing the interaction of an incoming wave with the composite vertical breakwater, for one sample experimental test.

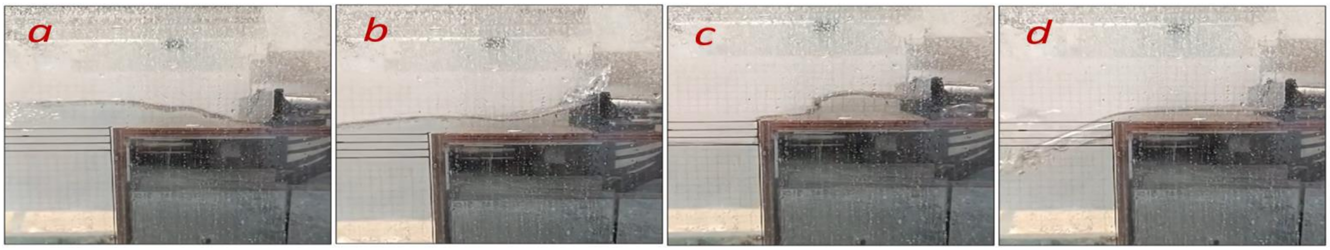

Figure 1 Snapshots of wave interaction on a vertical structure with retreated parapet: a) propagation of the «bore» towards the retreated wall. b) impact of the «bore» on the retreated wall. c) reflection of the mass of water by the wall. d) formation of the sub-horizontal jet.

2 RESULTS

The analysis of the data collected during the experimental campaign is currently ongoing. The first experimental evidences seem to confirm and expand the findings of Romano and Bellotti (2023). The analysis of the force and moment signals, the pressures signals (an example is shown in Figure 2) and diagrams, the reflection coefficients as a function of the wall position, and the wave overtopping will provide valuable insights for design guidelines or recommendations for this technical solution. These will be presented and discussed at the Conference.

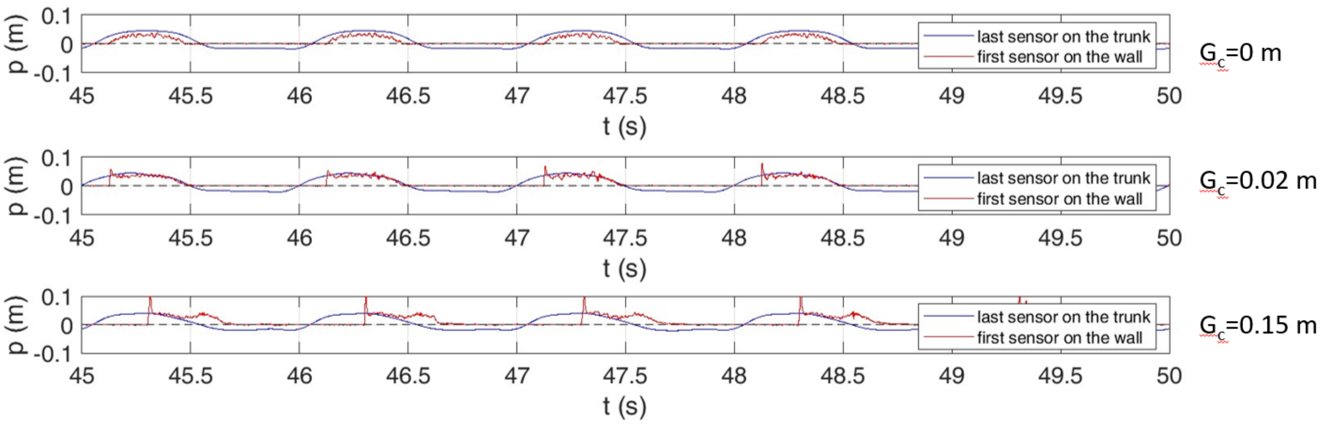

Figure 2 Pressure signals measured on the last pressure sensor of the trunk and the first of the wall: same sea state compared for various retreats of the crown wall (Gc)

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