Numerical experiments on overhanging parapets under non-breaking wave conditions.

Myrta Castellino, "Sapienza" Università di Roma, myrta.castellino@uniroma1.it
Alessandro Antonini, Delft University of Technology, a.antonini@tudelft.nl
Daniele Celli, University of L'Aquila, daniele.celli@univaq.it
Dimitrios Dermentzoglou, Delft University of Technology, d.dermentzoglou@tudelft.nl
Davide Pasquali, University of L'Aquila, davide.pasquali@univaq.it
Marcello Di Risio, University of L'Aquila, marcello.dirisio@univaq.it
Paolo De Girolamo, "Sapienza" Università di Roma, paolo.degirolamo@uniroma1.it

INTRODUCTION

Sea-wall and storm-wall structures aim to protect coastal areas and harbours from wave attacks. They are often located in the neighbours of city centres, that in turn impose rather severe visual limits affecting the maximum height of the structure. To combine the architectonical visual restrictions and the overtopping safety limits, imposed by different national standards, alternative solutions such as recurved parapet are often applied. Even for non-breaking wave conditions, these structures are subjected to large impulsive pressure that has been recently described and named as Confined-Crest impact, (C-CI, Castellino et al., 2018). The C-CI has been the cause of recent failures such as in the Civitavecchia harbour (Italy, Castellino et al., 2021 and Dermentzoglou et al., 2020). Accordingly, this phenomenon raised the attention of researchers and professionals who require an additional tool to design these curvilinear structures by considering the overtopping reduction performance, the structure complexity and the C-CI.

METHODS

A series of non-breaking regular waves numerical tests to investigate the induced reduction on the individual overtopping volume and the exerted impulsive wave force on the recurved parapet have been performed. The simulation of regular waves requires a low number of waves (about 15) since it has been observed that the highest pressure/force values occur in the first transient part of the simulations.

Four different geometries have been tested: i) Rectilinear parapet (Figure 1, upper right sketch), characterized by a horizontal overhang directed seaward; ii) Recurved parapet (Figure 1, upper left sketch), characterized by a single curvature; iii) Recurved crownwall (Figure 1, lower left sketch), characterized by a double curvature; iv) Vertical parapet (Figure 1, lower right sketch), characterized by a plane wall. Recurved and rectilinear parapets are often used in Italian harbours due to their high hydraulic efficiency and low construction costs. Recurved crownwalls are typical of the British sea walls and have not been investigated in-depth yet as crownwall of vertical wall breakwaters. The comparison against the performance with a standard vertical parapet is adopted to highlight the pros and cons of the overhanging shapes.

The numerical simulations are performed by using OpenFOAM and IHFOAM for wave generation and absorption (Higuera et al., 2013). The tests are performed on a prototype scale. The numerical wave flume is characterized by a length of 200 m and a height of 44 m. Each of the four structures has been considered an impermeable object together with the bottom of the wave flume.

The numerical tests have been validated against experimental tests described in the submitted abstract: Antonini et al., "Physical experiments on overhanging parapets under non-breaking wave conditions", presented in the abstract n. 1603.

RESULTS

The preliminary results show a significant reduction of the overtopping (lower right plot of Figure 1), in terms of individual overtopping volume. Furthermore, it can be observed that the wave overtopping reduction seems to be not so much correlated to the shape of the wall but to the overhanging extension of the shaped parapet wall.

However, this improvement of the structure performance indicated some drawbacks. We detected an increment of the peak force between 2.5 and 5 times the quasi-static one recorded on the vertical parapet, whereas the maximum overtopping volume is reduced by 10-40 %.

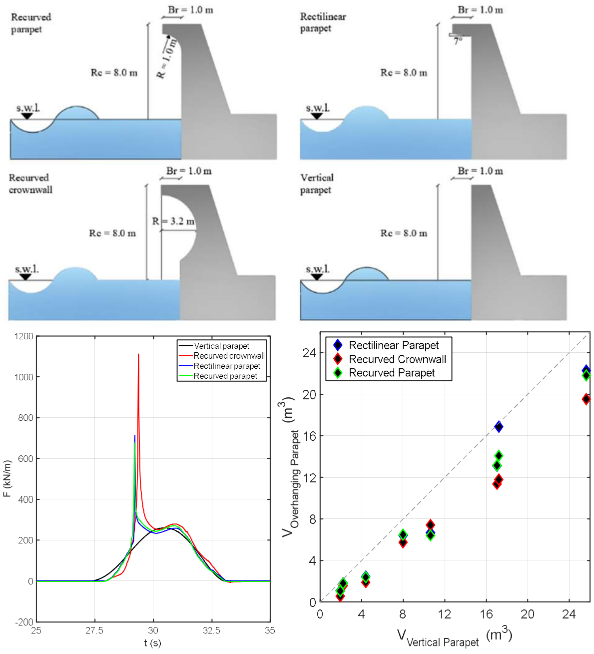

Figure 1 - Analyzed geometries (upper figures) and main results (forces and wave overtopping).

As shown in the lower left panel of Figure 1, the highest force increment is related to the recurved crownwall. This result can be justified by the fact that this configuration is characterized by the greatest surface extension.

In Figure 2, the non-dimensional force F* is represented as a function of the wave steepness. F* has been calculated as the ratio between the maximum force obtained for each of the shaped parapets and the maximum force on the vertical parapet:

$$F^* = \frac{F_{max}^{Shaped\ Parapet}}{F_{max}^{V}}$$

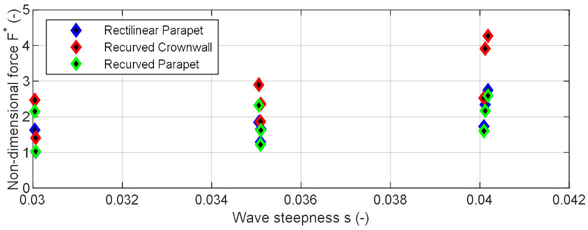

Figure 2 - Non-dimensional forces F* represented as a function of wave steepness s.

On average, the maximum force increment with respect to the vertical configuration is given by the Recurved crownwall.

The analysis performed on a wide range of wave conditions, both with the aim to describe the different physical phenomena generating the C-CI and the effects of the wave characteristics on wave overtopping will be presented at the conference. Moreover, a critical reflection on the importance of the peak pressure vs the impulsive pressure on the design process will be provided, aiming to stimulate the discussion on how these metrics should be considered for a realistic design process.

REFERENCES

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