Wave induced loads on recurves atop a seawall on a sloped seabed

Dimitris Stagonas, Depart. of Civil and Env. Eng., University of Cyprus, Cyprus, stagonas.dimitris@ucy.ac.cy
Gerald Muller, Depart. of Civil and Env. Eng., University of Southampton, UK, g.muller@soton.ac.uk

ABSTRACT
The current work adds on previous research and presents large scale experimental results of wave induced forces on a recurve atop a seawall at the end of a sloped approaching bed. In addition to the experimental results a theoretical expression for predicting the violent wave induced loads is also reported.

KEYWORDS
Recurves, violent wave loads, breaking waves.

INTRODUCTION
Wave recurves are elements of coastal defenses used for reducing overtopping without substantially increasing the structure's freeboard. Recurves, can be retrofitted in existing structures or be part of the initial design of the structure. In contrast to parapets – a term most commonly used to describe a low vertical protective element on top of a structure – and in particular chamfered parapets, recurves are characterized by a curved shape aiming to gently deflect seawards the up-rushing (to i.e. the seawall) water, Figure 1.
A number of wave induced failure examples associated with overturning and/or sliding of recurves have been reported in Castellino et al. (2018). The later authors have also reported the generation of impulsive loads by non-breaking waves on recurves located at the top of caissons and over a flat bed. In contrast, the current paper reports on large scale experimental results considering (three) recurves with different geometries atop a seawall at the end of a sloped bed. The shoaling process allowed for the generation of non-breaking, breaking and broken waves, enabling the observation and evaluation of the loading on the recurves.
Previously, Ravindar et al. (2020) focused mostly at the distribution of pressures at the underside of these recurves, and emphasis now is given on the wave induced forces. A simplified theoretical expression for calculating wave impact induced loads on the recurves is also reported and the predictions are compared with the experimental measurements.

METHODOLOGY
The experimental investigation was undertaken in the Large Wave Flume (GWK) of the Forschungzentrum Küste (FZK), Hannover, Germany, via the EU FP7 HYDRALAB IV transnational access project. The flume is 307m in length, 7m in depth and 5m in width and is equipped with a piston type wavemaker the motion of which is adjusted by an active wave absorption system to absorb reflected waves.
A model seawall was placed 243m from the wave-maker and tests were conducted with three recurves retrofitted at the top of the seawall, see for example Figure 1. The seawards edge of the smallest, the medium and the largest recurve extended beyond the seawall's vertical plane by 0.2m, 0.4 m and 0.61m, respectively.
All experiments were conducted with a 1:10 approaching slope stretching 33m in length and 3.3m in height at the location of the wall. Surface elevation was measured with 12 wave probes sampled at 100Hz, while 5 load cells were used to measure wave loads on a 0.7m segment of each recurve.
Finally, the simplified theoretical expression builds on momentum theory and on the physical characteristics of the up-rushing wave induced water jets to determine the maximum force acting on the recurve.

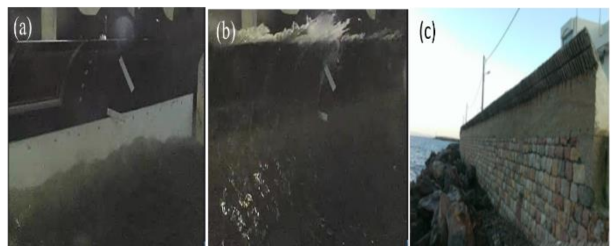

Figure 1 – (a) and (b), a model recurve on a seawall deflecting wave induced up-rushing water in the large scale experiments at GWK, FZK, Hanover, Germany. (c) a damaged chamfered parapet at the port of the island of Chios, Greece.

RESULTS AND CONCLUSIONS
Wave recurves are becoming more important structural elements of coastal protection structures since they allow reducing overtopping significantly. In the same time, little seems to be known about the forces acting on the recurves which leads to failures. The experimental results presented here, suggest that impulsive conditions at the seawall lead to impulsive conditions at the recurve(s) and high peak loads imparted by the up-rushing and then deflected water jets. The simplified theoretical expression reported, is a strong simplification of reality but it suggests the existence of a maximum force of the deflected jet and it quantifies this force as a function of the deflection angle and the incoming wave characteristics.

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