

A NEW REDUCTIVE FACTOR FOR THE WAVE OVERTOPPING DISCHARGE AT CROWN WALLS BASED ON GENETIC PROGRAMMING

Sara Mizar Formentin, University of Bologna, saramizar.formentin2@unibo.it
Barbara Zanuttigh, University of Bologna, barbara.zanuttigh@unibo.it

AIM AND MOTIVATION

The upgrade of existing coastal defense structures by including crown walls and parapets may represent an effective and economic solution to reduce the wave overtopping discharge q (Van Doorslaer et al., 2015). Recently, Formentin & Zanuttigh (2019) have developed a coefficient γ_{GP}^* for the parametrization of the effects induced by berms or promenades, crown walls and parapets on the average q . The formula for γ_{GP}^* was obtained from the Genetic Programming (GP) technique and was conceived to be included in the q formulae by EurOtop (2018). The formula has been applied so far only to smooth dikes with crown walls, i.e. for values of the roughness coefficient $\gamma_f=1$ (see Fig. 1a).

The aim of this contribution is to investigate the extension of the formula for γ_{GP}^* to a wider range of coastal structures, such as crown walls on top of rubble mound breakwaters (Fig. 1b) and vertical seawalls (Fig. 1c). The ultimate objective is to provide a new design factor to be used in the EurOtop (2018) formulae.

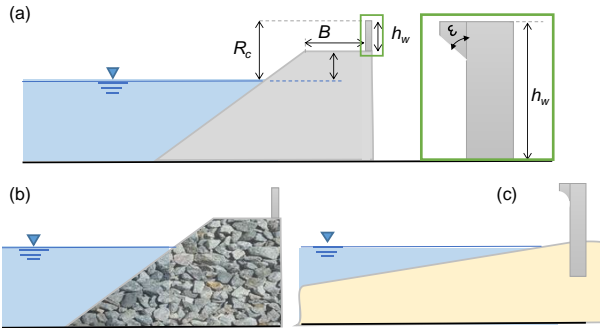


Figure 1 - Scheme and parameters of the structures to be represented with γ_{GP}^* .

METHODOLOGY

The GP is a machine-learning technique which can be trained to deliver algebraic formulae to estimate a specific parameter by performing a symbolic regression of data (Pourzangbar et al., 2017). Formentin & Zanuttigh (2019) applied this technique to derive the following formula:

$$\gamma_{GP}^* = \frac{0.93}{\tanh(1.5 \cdot \xi_{m-1,0})} - 0.3 \cdot \tanh\left(\frac{B}{L_{m-1,0}}\right) - 0.4 \cdot \tanh\left(\frac{h_w}{R_c}\right) - 0.15 \cdot \varepsilon \quad (1)$$

to model the reducing effects of: a promenade or a berm, through the parameter $B/L_{m-1,0}$, representing the berm width above the wave length; a crown wall through the ratio h_w/R_c , between the wall height and the total structure freeboard; a parapet, represented by the angle of inclination of the parapet with respect to the vertical, ε ; the wave breaking, by means of the Iribarren-Battjes breaker parameter $\xi_{m-1,0}$.

The use of the coefficient γ_{GP}^* in the EurOtop (2018) equations for q at smooth dikes showed an improved performance with respect to existing methods (e.g., Van Doorslaer et al., 2015).

The formula (1) is here applied to datasets included in the EurOtop (2018) database that represent different structures, to check the capability of generalization of γ_{GP}^* . These structures include specifically: a seawall protected by a rubble slope; a permeable berm with recurved seawall on top; a smooth dike with crown recurved wall; a recurved return wall with a rock revetment; a rubble mound revetment with a berm in front of a seawall with parapet, for a total of 334 tests.

ANALYSIS AND PRELIMINARY RESULTS

The performance of the formula for γ_{GP}^* is qualitatively assessed by displaying the distribution of the predictions q_{GP} versus the measured values q_{meas} for each dataset in Figure 1. The agreement among predictions and measurements is remarkable, being the values of R^2 always >0.70 and on average between 0.83-0.96, i.e. comparable to the performance obtained on smooth dikes (Formentin & Zanuttigh, 2019).

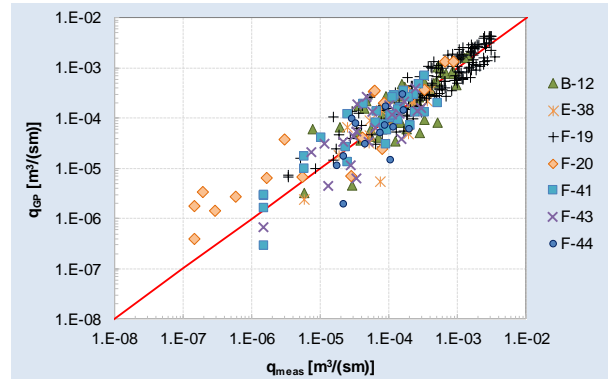


Figure 2 - Predictions of q (q_{GP}) compared to the related measurements (q_{meas}) for the selected tests.

REFERENCES

- EurOtop (2018). Manual on wave overtopping of sea defences and related Structures. Second Edition. Allsop, Bruce, DeRouck, Kortenhaus, Pullen, Schüttrumpf, Troch, Van der Meer and Zanuttigh.
- Formentin and Zanuttigh (2019). A Genetic Programming based formula for wave overtopping by crown walls and bullnoses, Coastal Engineering 152, 103529.
- Pourzangbar, Losada, Saberc, Rasoul Aharid, Larroudé, Vaezif and Brocchini. (2017). Prediction of non-breaking wave induced scour depth at the trunk section of breakwaters using Genetic Programming and Artificial Neural Networks, Coastal Engineering 121, 107-118.
- Van Doorslaer, De Rouck, Audenaert and Duquet. (2015). Crest modifications to reduce wave overtopping of non-breaking waves over a smooth dike slope, Coastal Engineering, 101, 69-88.