

A SIMPLE METHOD TO MEASURE INSTANTANEOUS WAVE OVERTOPPING

Marcello Di Risio, University of L'Aquila, marcello.dirisio@univaq.it
 Daniele Celli, University of L'Aquila, daniele.celli@univaq.it
 Carmine Di Nucci, University of L'Aquila, carmine.dinucci@univaq.it
 Davide Pasquali, University of L'Aquila, davide.pasquali@univaq.it

INTRODUCTION

Wave overtopping is one of the main phenomena influencing the performance of harbor structures in protecting the sheltered area (EurOtop, 2018). Indeed, the configuration of such a kind of structure is often selected to limit the wave overtopping that could threaten the safety of activities performed in harbors (Buccino et al., 2023). Usually, the wave overtopping is quantified by referring to the mean overtopping rate, the individual wave overtopping volume, and the thickness and velocity of the overtopping jet (e.g. Schüttrumpf et al. 2002; Mares-Nasarre et al., 2019; Altomare et al., 2020).

On the one hand, the recent development of numerical modeling (both hardware and software) opens the door to a detailed description of the complex processes of wave overtopping. The whole flow can be then (numerically) characterized by gaining insight into the instantaneous features of the hydrodynamics of wave overtopping (e.g. Chen et al., 2021).

On the other hand, wave overtopping is measured within experimental investigations by collecting the overtopped volume in a tank deployed on the rear side of the tested structures and connected to its crest by means of a sloping tray. The volume is then measured by means of load cells or by wave probes installed into the collecting tank (e.g. Di Risio et al., 2007). Detailed and instantaneous features of wave overtopping may be observed only by employing specific devices (e.g. Chen et al., 2021).

A simple measurement of instantaneous features of wave overtopping may be precious to numerical validation purposes and to further characterize the phenomenon (i.e. the average velocity of the overtopping flow).

This work aims to propose a simple method to measure the instantaneous features of overtopping events. The method relies on the use of a specific experimental device designed to provide a semi-empirical model with the needed information to get the instantaneous overtopping discharge flowing at the crest of the investigated structure.

METHODS

The method relies on the (global) continuity equation written for a control volume materialized with a sloping tray deployed on the rear side of a maritime structure. Figure 1 depicts the sketch of the problem. The temporal derivative of the instantaneous mass (M) of water contained in the control volume can be related to the instantaneous water discharge entering through the upstream boundary (ρQ_i , with ρ the water density and Q_i the volumetric discharge at the inlet section) and the one leaving the control volume through the downstream

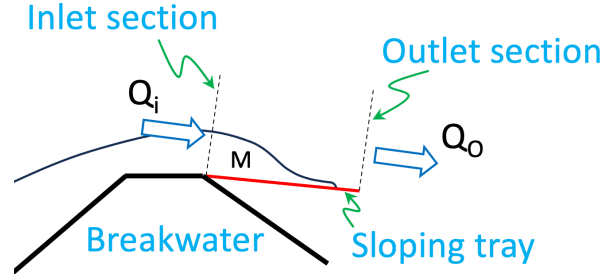


Figure 1 - Sketch of the problem with the involved parameters

boundary (ρQ_o , with Q_o the volumetric discharge at the outlet section):

$$\frac{dM}{dt} = \rho Q_i - \rho Q_o \quad (1)$$

Equation (1) can be written in difference form:

$$M^{(j+1)} - M^{(j)} = \frac{\delta t}{2} \rho (Q_i^{(j+1)} + Q_i^{(j)} - Q_o^{(j+1)} + Q_o^{(j)}) \quad (2)$$

where the superscript indicates the value of the mass or the water discharge at the time t_j ($=j\delta t$) and δt is the temporal step.

If the instantaneous mass in the sloping tray is known, equation (1) can be used to get the instantaneous difference of water discharge at the time t_{j+1} :

$$Q_i^{(j+1)} - Q_o^{(j+1)} = \frac{2}{\delta t} \frac{M^{(j+1)} - M^{(j)}}{\rho} - Q_i^{(j)} + Q_o^{(j)} \quad (3)$$

If the sloping tray is long enough with respect to the duration of the overtopping event (T_o), equation (3) can be used to estimate the water discharge flowing at the crest of the structure for $t_{j+1} < T_o$:

$$Q_i^{(j+1)} = \frac{2}{\delta t} \frac{M^{(j+1)} - M^{(j)}}{\rho} - Q_i^{(j)} \quad (4)$$

If the sloping tray is not long enough, an empirical model can be employed to describe the temporal variation of the outlet water discharge based on the estimation given by equation (3) for $t_{j+1} > T_o$:

$$Q_o^{(j+1)} = -\frac{2}{\delta t} \frac{M^{(j+1)} - M^{(j)}}{\rho} - Q_o^{(j)} \quad (5)$$

Figure 2 shows the prototype of the experimental device deployed at the Environmental and Maritime Hydraulic Laboratory of the University of L'Aquila. The mass of water contained in the sloping tray is measured by means of a load cell.

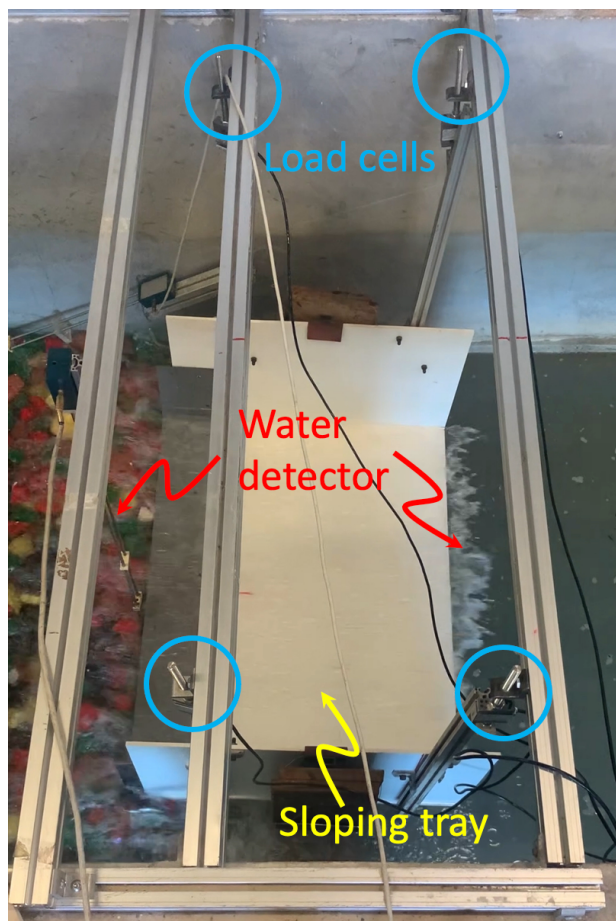


Figure 2 - Prototype of the proposed device

The upstream boundary of the sloping tray a water detector allows to identify the duration of the overtopping event.

The synchronous signal of the water detector deployed at the downstream boundary allows to check if the sloping tray is long enough to use equation (4) or if the empirical model for the outlet water discharge is needed.

The validation of the proposed method is ongoing by means of an ad hoc experimental investigation and by means of a series of numerical simulations performed by DualSPHysics (e.g. Domínguez et al., 2022) and the main results will be presented at the conference.

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