WAVE OVERTOPPING AT VERTICAL STRUCTURES: COMPARISON OF DIFFERENT FORMULAS

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INTRODUCTION

Wave overtopping is considered an important aspect when designing waterfront or sea-defense structures. This is mainly due to the associated risks in the provision of necessary protection and safety measures for properties and people. Hence, a part of any design procedure is to predict the overtopping rate. Currently, there are various formulas with different applicability range and complexity level to predict the overtopping rate based on environmental, structural and wave characteristics and conditions. Because overtopping is quite a complex phenomenon, most of the previous studies were focused on deriving empirical formulas using data collected from laboratory tests. The most extensive collection of such tests was provided by the CLASH project database (van der Meer et al., 2009) for the first time. Later, an update of this database was released (i.e. the European Overtopping Manual; EurOtop, 2018), encompassing about 18000 records of laboratory and field tests for various types of coastal structures. This paper, in particular, deals with the estimation of overtopping at vertical structures, and considers four of the existing methods (i.e. Goda 2009, van der Meer and Bruce 2014, Etemad-Shahidi et al. 2016, and EurOtop 2018); while their performance has not been thoroughly investigated using an extensive database for the specific case of vertical structures.

DATASET AND METHOD

In preparation for the specific dataset of this study, the first step was to select and filter records of EurOtop database relevant to vertical structures. That is, the sea-side face of the structure needs to be vertical; which is shown by the angle α in the EurOtop database, and cot(α) should be zero for these structures. Moreover, particular subsets of the EurOtop database records were also excluded; comprising 1) records with overtopping rates lower than 10^{-6} $m^3/s/m$, due to high possibility of flawed measurements, 2) field-measurements due to the possible influence of scale factors (e.g. Etemad-Shahidi and Bali, 2012), and 3) any record with the lowest complexity (CF) and reliability (RF) factors (i.e. 4). Applying these filters result in about 1100 records. Using the formulas provided by Goda (2009), van der Meer and Bruce (2014) (here is referred to as VB), Etemad-Shahidi et al. (2016) (using both of their equation sets, which here are referred to as ESJ1 and ESJ6) and EurOtop (2018) (here is referred to as ET), the overtopping rate was estimated for each of the selected records to be compared with measured values. For a quantitative comparison, performance measures such as *BIAS*, *RMSE* and discrepancy ratio (*DR*, which is the ratio of the predicted and measured values) were used. Both *BIAS* and *RMSE* provide an overall view of the performance (where zero is their best value) and describe how well, in general, a formula performs, while *DR* is calculated individually for each record and its optimum value is one. Since overtopping is a complex phenomenon and its prediction is a challenging task, generally speaking, predicted values up to one order of magnitude larger or smaller than the actual measured figures (corresponding to $-1 \le \log(DR) \le 1$) are still considered acceptable. The percentage of the record numbers in the above range can also be used as another quality metric (where 100% is the best value).

RESULTS

The obtained results showed that the *BIAS* values of 0.01, 0.02 and 0.03 corresponded to ET, ESJ6 and Goda formulas, respectively. However, the *RMSE* values of 0.51, 0.57 and 0.71, along with the largest percentages of DR values in the accepted range (i.e. 94%, 92% and 87%) were obtained for ESJ6, ESJ1 and Goda formulas, respectively. These suggest that overall ESJ6 performs better than other formulas. It should be noted that even though Goda's equation was not calibrated for the entirety of the used dataset, it performs well and is relatively simple. Detailed analyses of the results, along with the derivation of a new formula set can be found in Shaeri and Etemad-Shahidi (2020).

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