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Negro Valdecantos, López Gutiérrez, Polvorinos Flors and Molines

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Discussion: Comparative study of breakwater crown wall – calculation methods

Vicente Negro Valdecantos DCivEng
Associate Professor, Technical University of Madrid, Madrid, Spain

José Santos López Gutiérrez DCivEng
Assistant Professor, Technical University of Madrid, Madrid, Spain

Jose Ignacio Polvorinos Flors PhD
Technical University of Madrid, Madrid, Spain

Jorge Molines MEng
Research Assistant, Department of Transportation, Technical University of Valencia, Valencia, Spain

Contribution by Jorge Molines

This paper (Negro Valdecantos *et al.*, 2013) presents an extensive and useful comparison of existing formulas to estimate wave forces on crown walls. The paper also provides valuable insights into crown wall behaviour, suggesting the use of formulas for prior sizing and recommending, in any case, tests on a physical model in order to confirm the final design. The authors helpfully advise to use more than one method to obtain results closer to reality, always taking into account the test conditions under which each formula was developed.

The authors suggest considering the addition of the methods of Pedersen (1996) and Molines (2011) to the reviewed literature, both based on irregular tests. Pedersen (1996) conducted a deep analysis of crown wall stability and proposed a method to estimate the 0·1% wave forces, which Camus Braña and Flores Guillén (2004) gave as the most reliable one. Molines (2011) compared existing methods and proposed a formula using pruned neural networks to estimate the 0·1% horizontal and vertical force. The peak value of both forces was considered simultaneously, thus being on the safe side.

Focusing on the method of Martín *et al.* (1995), Martín *et al.* (1999) proposed some variations on their formula. Martín *et al.* (1999) detailed the influence of submerged foundations and considered the dynamic response of the structure on the design wave forces (through the parameter α given in this paper by Equation 10). This method was initially developed for regular waves, and was extended to irregular waves through the hypothesis of equivalence in Martín *et al.* (1995, 1999).

When possible, the authors recommend specifying the force percentile that is estimated by each formula: that is, Bradbury and Allsop (1988), Pedersen (1996) and Molines (2011) estimate the percentile 0·1%, whereas Berenguer and Baonza (2006) estimate the maximum force. Formulas based on regular tests are not directly associated to a probability level of exceedance and need a methodology to be statistically characterised (i.e. the one described in Martín *et al.* (1995, 1999)). This consideration could add practical insights to those given by the authors, in order to compare the same percentile force for all methods in the hope of avoiding misunderstandings.

Authors' reply

The investigations reported in Negro Valdecantos *et al.* (2013) were actually completed and first reported on in 2010, that is before the method of Molines (2011) had been published, so therefore could not have been reviewed at that time. Methodology developed by Pedersen (1996) certainly provides a deep study of the problem.

The addition of both methodologies will enrich current and future research on the crown wall topic.

Certainly, Martín *et al.* revised the parameter α to include the dynamic response of the crown wall, which represents another step in the study of the problem. However, it must also be added and taken into account that the authors point out that further research on this new issue is required.

Regarding the force percentile, as explained in Negro Valdecantos *et al.* (2013), it was decided to maintain the notation used by the authors in their original papers. The probability level of exceedance and force percentile have been included only in those methods in which the authors indicate them; for example, the horizontal force $F_{h,0\cdot1\%}$ in Pedersen and Burcharth (1992) or the ascent of the sheet of water $R_{u2\%}$ in Berenguer and Baonza (2006).

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