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Summary

An investigation of wave overtopping of marine structures is described. Focus is put on structures with relatively low crest levels and various slope layouts subjected to non-breaking waves. Influence of slope draught and angle is investigated.

Keywords: Wave overtopping, model tests, low crested structures, non-breaking waves.

1 Introduction

Investigations of wave overtopping of coastal structures have been the object of numerous investigations over the past 50 years starting out with experimental studies of shore structures using regular waves, Saville and Caldwell (1953). Since then up to present the overtopping prediction tools for typical sea defense structures have continuously been refined. Among the most recent and most recognized works are Owen (1980) and Van der Meer & Janssen (1994). More comprehensive overviews are given by Van der Meer (1998) and Burcharth and Hughes (2000).

Many of the previous investigations have resulted in an exponential relation between a non-dimensional overtopping rate Q and a non-dimensional crest freeboard of the structure R (given in the form $Q = A\, e^{-BR}$). The parameters used for the non-dimensionalisation of Q and R are various. A majority of the investigations recommend a set of A and B coefficients with some reduction coefficients to take various changes of geometries or wave climate parameters into account.

Consequently results from literature can be presented on the form $\frac{Q}{\lambda_1 \lambda_2 \ldots \lambda_n} = \mathrm{A}\, \mathrm{e}^{-\mathrm{B}\frac{\mathrm{R}}{\gamma_1 \gamma_2 \ldots \gamma_m}}$ where A and B are universal coefficients and all variations are introduced through the λ and γ coefficients. This idea is further discussed in the paper.

The work described in the paper has been motivated by questions raised by developers of wave energy devices utilizing wave overtopping for production of electrical power. Motivated by the fact that a number of the wave energy devices subsided by the Danish Wave Energy Program utilizes wave overtopping, a project was formulated to investigate overtopping with respect to the optimizing the amount of potential energy obtained in the overtopping water. In the literature the vast majority of the overtopping investigations have focused on structure designs that minimize the amount of overtopping and wave situations where small or moderate amounts of overtopping occur. Furthermore, a number of the proposed wave energy devices utilizing overtopping are floating structures, which means that the structure is not extending all the way to the seabed, but has a limited draught. It has been found that no information is available in the literature on how to estimate overtopping of such structures.

On this background a physical model study has been performed in which it is investigated how a wide range of different geometric parameters influence the overtopping volume when the structure is subjected to heavily varying wave conditions. Furthermore, it is investigated how these new results fits in the results reported in the literature.

2 Conclusion

By use of model tests wave overtopping of non-breaking waves on a straight slope have been investigated. The effect of limited draught and the angle (in combination with a limited draught) of the slope on the overtopping rate have been investigated. An expression taking into account these effects is presented.

Furthermore, the results of the performed model tests have been compared to existing overtopping investigations. The model tests have "closed a gap" between existing investigations for low crest freeboards, and an overtopping expression for non-breaking waves have been proposed. This expression enables prediction average overtopping rates for relative crest freeboards down to 0. The proposed expression also includes effect of limited draught and the angle (in combination with a limited draught) of the slope.

3 Acknowledgements

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4 References

Burcharth, H. F. and S. Hughes (2000). *Coastal Engineering Manual, Fundamentals of Design. Chapter 5, Part VI.* To be published by Coastal Engineering Research Center, Waterways Experiment Station, US Army Corps of Engineers,Vicksburg, USA.

Owen, M. W. (1980). *Design of Sea Walls Allowing for Wave Overtopping*. Rep. EX 924, HR Wallingford.

Saville, T. and J. M. Caldwell (1953). *Experimental study of wave overtopping on shore structures.* Proc. Minnesota Int. Hydraulics Conv., IAHR, ASCE, Minneapolis, Minnesota, USA.

Van der Meer, J. W. (1998). *Wave Run-Up and Overtopping. Chapter 8 in Dikes and Revetments, Design, Maintenance and Safety Assessment.* Ed. K. W. Pilarczyk, A. A. Balkema, Rotterdam, Brookfield.

Van der Meer, J. W. and J. P. F. M. Janssen (1994). *Wave run-up and wave overtopping of dikes.* Wave forces on inclined and vertical wall structures, ed. N. Kobayashi and Z. Demirbilek, pp. 1 – 27, ASCE. Also Delft Hydraulics, Publ. No. 485.