LABORATORY EXPERIMENTS OF WAVE OVERTOPPING OF REVETMENT STRUCTURES IN REEF ENVIRONMENTS

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INTRODUCTION

Reefs offer natural protection to many coastal island nations through the physical processes of wave breaking on the reef rim and thus, reducing the wave energy that reaches the shoreline. However, both mean and infra-gravity water levels build up over the reef due to wave breaking on the reef top that can lead to coastal inundation and serious damage (Gourlay 1996a; Gourlay 1996b; Blacka et al. 2015). To protect the community around the coastal region, the construction of defensive structures, such as revetments or sea dikes may be required. The present study is focused on wave overtopping discharge on smooth revetments within the reef environment, which is not fully understood. Classical formulas that estimate overtopping of revetments (see Van der Meer et al. 2016 and references therein) are based on waves breaking in deep to shallow water either in front of the structure or directly on the structure. Recently, Altomare (2016) updated Van Gent's (1999) formula of overtopping discharge of smooth sea dikes on shallow foreshores to include very shallow foreshores. The updated equation estimates dimensionless over-topping as a function of the full spectrum wave properties at the toe of the structure and an equivalent slope term. As the reef environment can often be described as a very flat and shallow lagoon seaward of the shoreline, the Altomare formula can potentially be adopted to predict the overtopping discharge on smooth revetments in reef environments, but this has yet to be tested.

METHODOLOGY

To assess the feasibility of the equation, a physical modelling study (1:50 Froude scale) was undertaken in the 1.2m wide by 40m long wave flume at the Water Research Laboratory, UNSW Sydney. For simplicity, all values herein will be quoted in prototype scale. An idealized reef profile of Avarua Rarotonga, Cook Islands was used as the representative reef profile. Smooth revetment structures were placed at the landward edge of the reef widths of 75 and 150m. Four independent removable revetments were tested that included a 5m and 10m high revetment each with a 1V:3H and 2V:3H slope. Various wave conditions with adjusted still water level (SWL) were tested during the experiment based on simulation of extreme wave conditions during 1987 TC Sally and 100-year ARI. The range of conditions included offshore wave heights of 8 - 12 m, peak wave periods of 11 to 15 s, and SWL over the reef flat from 0.3 m to 2.1 m. Wave time series were generated assuming a Jonswap spectrum at the offshore boundary. Wave probes were located along the length of the flume to capture the transformation, dissipation and reflection of the waves on the reef from deep water. Overtopping rates (L/m/s) were calculated based on the measured volume of water captured in holding tanks at the back of the revetment for each test and accounting for the length of the test (1000 waves) and the width of the revetment.

RESULTS AND DISCUSSION

The results of the physical lab experiments show that overtopping rates increased with increasing wave period, narrower reef widths, shorter revetment heights and higher still water levels. The effect of revetment slope varied with water level.

Estimating overtopping using the Altomare (2016) formula produced similar trends to the observations, but with a clear revetment slope dependency. Comparing the observed overtopping rates with Altomare (2016) indicated that the updated empirical formula tends to overestimate the overtopping discharge on smooth revetment in reef condition (Figure 1). Possible causes for this over-estimation may be in the appropriate input wave height and period into the formula, with the reef environment dominated by low to very low frequency motions which may contribute, but not dominate the observed overtopping of revetments on reef environments.

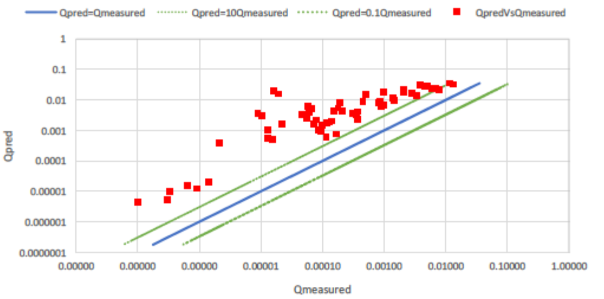

Figure 1. Comparison of observed and estimated over-topping rates based on Altomare (2016).

REFERENCES

Altomare, C. et al., (2016) Wave overtopping of sea dikes with very shallow foreshores. Coastal Engineering, 116, pp.236-257.
Blacka, M.J. et al., (2015) Estimating wave heights and water levels inside fringing reefs during extreme conditions. In Australasian Coasts & Ports Conference 2015. Auckland, NZ, pp. 83-89.
Van Gent, M., (1999) Physical model investigations on coastal structures with shallow foreshores: 2D model tests with single and double-peaked wave energy spectra, Delft, Netherlands.
Gourlay, M.R., (1996a) Wave set-up on coral reefs. 1. Set-up and wave-generated flow on an idealized two dimensional horizontal reef. Coastal Engineering, 27, pp.161-193.
Gourlay, M.R., (1996b) Wave set-up on coral reefs. 2. Set-up on reefs with various profiles. Coastal Engineering, 28, pp.17-55.
Van der Meer, J.W. et al., (2016) EurOtop 2016. Manual on wave overtopping of sea defences and related structures. An overtopping manual largely based on European research, but for worldwide application, Available at: www.overtopping-manual.com.