# ADVANCES IN COASTAL FLOODING AND OVERTOPPING INVESTIGATIONS USING A 3D PHASE-RESOLVING WAVE MODEL

Stephan Kistner, PRDW South Africa, skistner@prdw.com
Stephen Luger, PRDW South Africa, sluger@prdw.com
Stewart Walker, PRDW South Africa, swalker@prdw.com

## INTRODUCTION

In engineering applications, runup and overtopping rates are often estimated from empirical parameterizations which rely on simplified assumptions of the incident wave conditions and can only be applied to a limited range of cross-shore profiles and simplified structural configurations. This study demonstrates the accuracy of DHI's MIKE 3 Wave FM (M3WFM) model for runup and overtopping applications by comparison to physical model and prototype measurements. Subsequently the model has been used in more than six projects involving coastal flooding and overtopping investigations with applications in structural design, setback lines and response to climate change.

## VALIDATION

The M3WFM model is a phase-resolving 3D wave model using a Reynolds-averaged Navier-Stokes (RANS) solver. The model was validated against two tests each of runup and overtopping, run as numerical flumes. In the first runup test the model was validated against prototype measurements from the SandyDuck'97 experiment (Stockdon & Holman, 2011), showing a good correlation to the measurements despite the 2DV simplification of 3D measurements. For the second validation case the model skilfully predicted runup on a steep, impermeable structure including wave breaking on an offshore bar (Van Gent, 1999). The model equally proved capable of reproducing measured overtopping rates over a solid vertical wall (Goda, et al., 1975) and a rubble mound breakwater (Aminti & Franco, 1988) - using a porous structure to simulate the armoured layer (Figure 1).
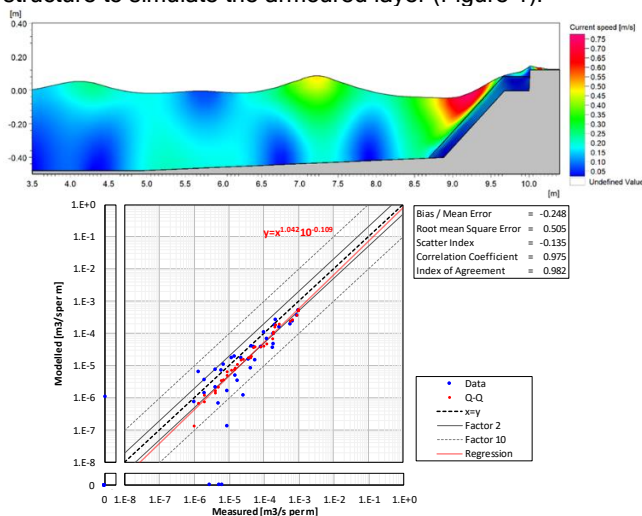


Figure 1 – Rubble mound breakwater: snapshot of modelled test case (top) and comparison of 44 modelled and measured overtopping cases (bottom) from experiments by Aminti & Franco (1988).

## CASE STUDY IN COASTAL FLOODING

A recent coastal modelling study used the M3WFM model to assess overtopping rates and the resulting flooding for inputs to a seawall design to mitigate climate change. In this project, the 3D solver was leveraged to transform waves in 12 m depth to overtopping waves, including the processes of refraction, shoaling, wave breaking, surf beat and reflection along the way (Figure 2, left). Since the model explicitly solves runup and overtopping of the seawall, the use of oversimplified wave conditions and cross-sections is no longer required. In contrast to the empirical alternatives, the numerical model also allowed for deeper analysis of the overtopping impacts, e.g., analysing the current speeds and flooding depths behind the wall, which allows for hazard classification to pedestrians, vehicles and structures, as well as testing drainage options for the overtopped water (Figure 2, right).
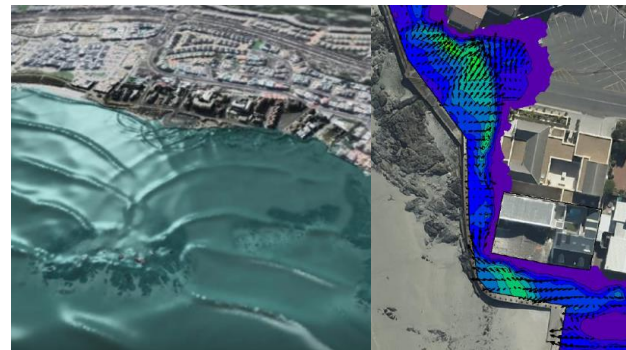


Figure 2 – 3D wave transformation (left) and overtopping of the seawall (right) showing the resultant current speeds and flooding depths.

## REFERENCES

Aminti, P. & Franco, L., (1988): Wave Overtopping on Rubble Mound Breakwaters, Coastal Engineering Proceedings, pp. 770-781.

Goda, Y., Kishira, Y. & Kamiyama, Y., (1975): Laboratory investigation on the overtopping rate of seawalls by irregular waves, Report of Port and Harbour Research Institute, Vol. 14, No.4.

Stockdon, H. & Holman, R., (2011): Observations of wave runup, setup, and swash on natural beaches, U.S. Geological Survey Data Series 602 [https://pubs.usgs.gov/ds/602/]

Van Gent, M., (1999): Physical model investigations on coastal structures with shallow foreshores: 2D model tests on the Petten sea-defence, Delft, Netherlands, Rijkswaterstaat, Dienst Weg- en Waterbouwkunde.