Proceedings of the 9th International Conference on Physical Modelling in Coastal Engineering (Coastlab24)
Delft, Netherlands, May 13-16, 2024

Extended Abstract**,** DOI: 10.59490/coastlab.2024.726

VALIDATION OF AN EFFICIENT NON-HYDROSTATIC WAVE MODEL AS A DESIGN TOOL FOR FORESHORES IN PHYSICAL MODELS

JOOST P. DEN BIEMAN[1], MENNO P. DE RIDDER[1,2], MADELIEF W. DOELEMAN[1]

1 Deltares, Department of Coastal Structures and Waves, The Netherlands, joost.denbieman@deltares.nl; menno.deridder@deltares.nl; madelief.doeleman@deltares.nl

2 Delft University of Technology, Department of Hydraulic Engineering, The Netherlands

KEYWORDS: Non-Hydrostatic Wave Model, Physical Model Test, Sloping Foreshore

1 INTRODUCTION

In the design of physical model experiments in coastal engineering, it is common that the construction of a foreshore is necessary to obtain the desired wave conditions at a given location, usually close to a structure being tested. In addition to the commonly used spectral wave parameters to describe the target wave conditions, the wave height distribution and associated parameters (such as H_{max} and $H_{2\%}$), wave periods and infra-gravity waves can be important to reproduce properly as well. Wave height distributions are typically important for tests where *e.g.* wave run-up or wave forces are of interest. Since the construction of foreshores is labour intensive (and thus expensive), it is useful to be able to check a priori whether the target wave conditions are met with a given foreshore design and whether the chosen transition slope does not significantly influence the wave conditions. One way to do this is by using numerical wave models.

For a numerical model to be a useful design tool for physical model layouts, the predicted wave transformation (over the foreshore) needs to be sufficiently accurate. One option is to use detailed CFD wave models for this purpose, such as OpenFOAM, which has been shown to accurately reproduce wave transformation (Jacobsen et al., 2015; Jacobsen et al., 2018). CFD models, however, typically feature high computational demand and consequentially computational times in the order of days. This is a significant disadvantage in the context of designing a physical model experiment, for which the layout and configuration is often an iterative process, which would be hampered by overly long computational times. On the other hand, spectral wave models, like SWAN (Booij et al., 1996), are much faster but do not model all the individual waves rendering it unable to model exceedance distributions. As a middle-ground, it seems that the XBeach model (Roelvink et al., 2009) used in its 2-layer non-hydrostatic mode (De Ridder et al., 2021) might present a workable compromise between computational time and accurate representation of the wave transformation. The model has been validated by De Ridder et al. (2021) on bichromatic waves, complex barred beach geometry and a fringing reef for bulk wave parameters and spectral properties.

Expanding on earlier validation work, in this work the ability of the XBeach 2-layer non-hydrostatic model (XBeach-nh) to reproduce wave height exceedance distributions over a sloping foreshore is validated using wave flume data, described in Sections 2 and 3. The preliminary results of the validation effort are shown in Section 4.

2 PHYSICAL MODEL SETUP

The physical model tests for the Sloping Foreshore (SloFor) experiments are performed in the Scheldt Flume facility at Deltares in Delft, the Netherlands. The wave board in the Scheldt Flume is equipped with Active Reflection Compensation and second-order wave generation. As is shown in the left panel of Figure 1, the model setup features a 1:15 transition slope and horizontal part, followed by a long 1:60 slope equipped with 15 wave gauges. Hence, the wave transformation on the slope is captured in relatively high spatial resolution. In the test program the wave steepness (s_{0p}) is varied between 1% and 5%, the relative water depth ($\frac{d}{H_{m0}}$) is varied between 3 and 4.5 and the tests are performed with two different water depths.

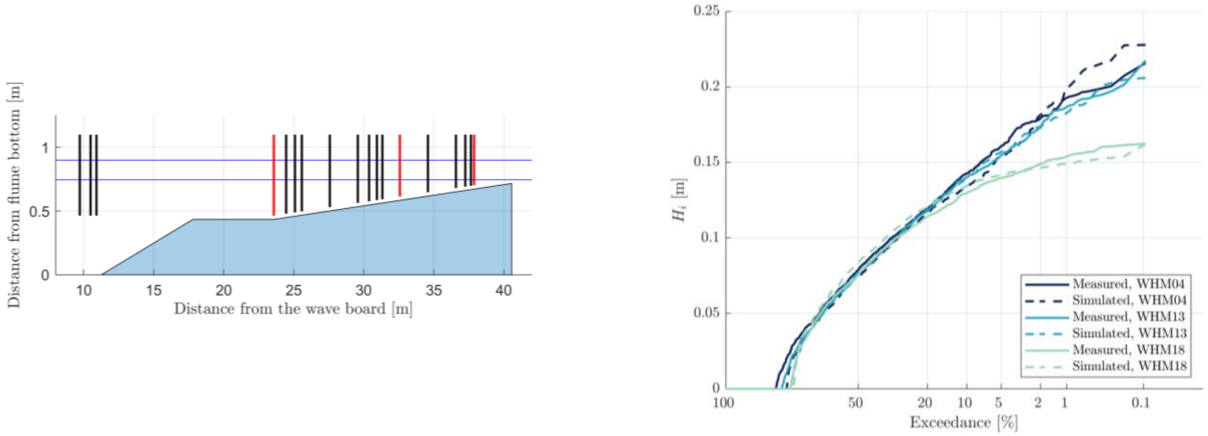

Figure 1. Left: the physical model, with the foreshore layout, tested water levels and wave gauge positions shown (with WHM04, WHM13 and WHM18 indicated in red). Right: wave height distributions at wave gauges along the slope for test D103.

3 VALIDATION OF THE NUMERICAL MODEL

The physical model tests are replicated in the XBeach-nh model. The surface elevation in the numerical model is evaluated at the exact same locations as the wave gauges in the physical model. The right panel of Figure 1 shows the wave height exceedance curves measured in the physical model and some preliminary results simulated by the 2-layer XBeach-nh numerical model. These preliminary results indicate that the numerical model can reproduce the measured wave height distributions reasonably well for both shallow water and deep-water conditions. Thus, the breaker formulation in XBeach-nh performs reasonably well.

4 CONCLUSIONS

Preliminary numerical model results are promising, showing reasonable to good matches of both spectral wave parameters and wave height distribution. The final work will include an extensive validation using all SloFor physical model tests, examining wave height distributions, wave spectra and associated spectral parameters. Furthermore, the suitability of an applicability limits of the 2-layer XBeach-nh model will be critically evaluated.

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