MODELLING WAVE ATTENUATION BY SALT MARSH VEGETATION

A POROUS LAYER APPROACH WITH COASTALFOAM

Salt marshes, known for their wave attenuation, offer a sustainable addition to traditional coastal protection. CoastalFOAM is a numerical CFD model to simulate sea waves. The goal is to develop a method which makes it possible to assess the effectiveness of salt marsh vegetation in mitigating wave overtopping and loads on dikes. However, CoastalFOAM is a 2D vertical model, posing challenges when modelling wave attenuation using the conventional 3D cylinder method. Nevertheless, the model can simulate flow velocity reduction in a stone layer by representing it as a porous layer. This leads to the research question: 'How can a porous layer within CoastalFOAM be effectively used to model wave attenuation during storm conditions by salt marsh vegetation at the foreshore of a dike?'.

In this approach, the porous layer represents the damping capacity of salt marsh vegetation. The Darcy-Forchheimer equation is used to quantify this damping effect. For stone layers, physical characteristics are defined by the median grain size (D_{50}) and porosity (n_p). Assuming a comparable scale for D_{50} and pore size, D_{50} can be equated to the distance between vegetation stems. Porosity is considered the ratio of the voids within the vegetation layer to the total volume of the vegetation layer.

The flume experiment in the paper of Möller et al. (2014) is selected as case study. Three tests are selected: the base case, a test with a higher wave and a test with lower vegetation height. The base case served as the calibration test for the model. Figure 1 shows a schematization of the numerical flume experiment. The model accurately replicated significant wave height reduction, peak wave period changes, and wave spectra (shown in Figure 2) for the base case. However, the calibrated model overestimated wave reduction for higher waves. This difference may be due to the assumption of rigid grass stems in the model, while real grass bends. To address this, a relationship between the calibration parameter β and stem bending was recommended. The test with a decrease in vegetation height resulted in an underestimation of wave reduction across the vegetation, potentially due to the integration of bottom friction effects in the porous layer or inaccurate plant bending representation. Decoupling bottom friction and the porous layer could mitigate the bottom friction issue. It was concluded that, although the model effectively represents wave attenuation for the base case, it requires recalibration to account for variations in hydrodynamic conditions or vegetation characteristics.

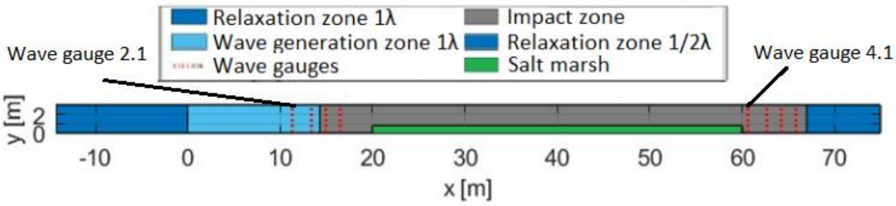

Figure 1: Visualization of the numerical wave flume

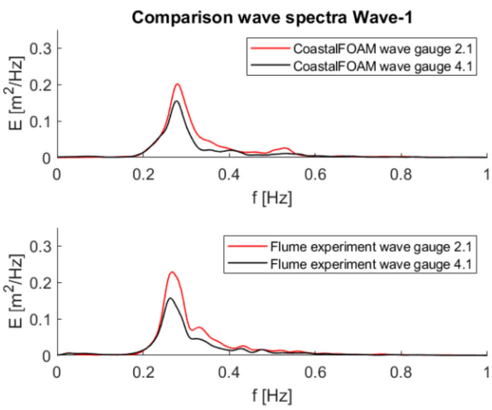

Figure 1: Predicted and measured wave spectra for the base case, before and after the vegetation.

Möller, I., Kudella, M., Rupprecht, F., Spencer, T., Paul, M., Van Wesenbeeck, B. K., Wolters, G., Jensen, K., Bouma, T. J., Miranda-Lange, M., & Schimmels, S. (2014). Wave attenuation over coastal salt marshes under storm surge conditions. Nature Geoscience, 7(10), 727–731. https://doi.org/10.1038/NGEO2251

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