IMPROVING ANALYTICAL WAVE DAMPING MODELS FOR WOODY VEGETATION

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RATIONALE

Including vegetation in front of dikes is a promising addition to stand-alone hard infrastructures for the safety against flooding. Vegetation dampens the incoming waves, alters velocity structures and enhances sedimentation. Besides this, it provides other ecosystem benefits such as increasing biodiversity and scenic values. However, these cannot be implemented yet as we need more accurate ways of predicting wave damping, especially during storm conditions. We need both hydraulic and vegetation measurements, where the latter is difficult for woody vegetation as they consist of more complex structures (i.e., branch densities, angles and tapering) than grassy vegetation.

Firstly, during storms, which are characterized by high water levels, the wave energy mainly goes through the canopies; thus, making them important to quantify. Still, less research has quantified the canopies and most research has been on schematizing solely the roots trunks (e.g. Yoshika, et al. 2021). For this, we need practical and accurate measuring methods.

Secondly, many studies on woody vegetation use field measurements which are generally in calm conditions or small-scale physical models that need upscaling. Upscaling of the results may lead to scale errors.

Lastly, trees modelled as 'stiff' cylinders, in numerical and physical models. However, a significant amount of swaying was observed during large-scale experiments on live willows (Van Wesenbeeck, et al. 2022). This implies that flexibility is not a parameter that can be easily disregarded.

OBJECTIVES

Part of the Woody project aims to improve existing analytical models for wave damping by woody vegetation. We will mainly focus on accurate vegetation input (i.e., frontal-surface area and flexibility) as well as quantifying the impact of these parameters on wave damping, and how to implement this in small-scale physical models. Thereto we also aim to identify possible scale effects during scaled physical modelling. Finally, these findings will be implemented in existing analytical formulations.

METHODS

For this, we use a combination of full-scale physical experiments and small-scale Cauchy-scaled experiments (1:10), shown in Figure 1. Large-scale experiments with live willow trees under storm conditions (Van Wesenbeeck, et al. 2022) are analyzed further. The wave damping by vegetation was measured during these tests, corrected for wall and bottom frictions of the flume. Besides this, detailed tree models were developed, as described in Kalloe et al. (2022). This description of the large scale tests was the main input for small-scale experiments. During these experiments, we measured the wave damping similar to the large-scale experiments. We also measured the branch motion in more detail during these scaled experiments.

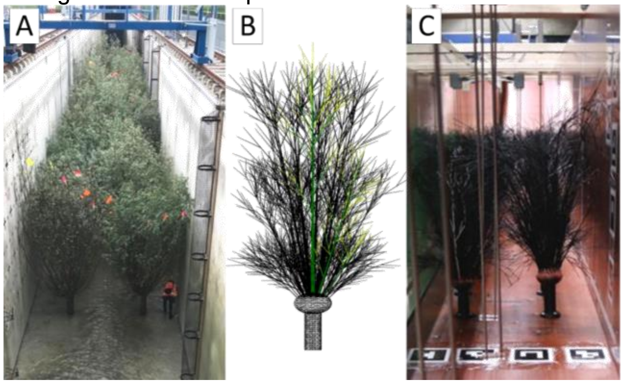

Figure 1 – A) Large-scale experiments with living trees (tree height, h_v = 5.3m), B) tree model, which is input to C) small-scale experiments with 3D-printed willows (h_v = 0.53m).

RESULTS AND CONCLUSIONS

Our main findings, show that detailed tree models are relevant for accurate frontal-surface area estimates; thus, for reliable wave predictions. Besides this, tree models are also useful for designing scaled physical models. The comparison between large-scale and small-scale experiments showed a large overestimation of wave damping on the smaller-scale, which we hypothesized to be due to more viscous damping. Furthermore, we argue that the flexibility is not constant along branch height, which can influence the damping as well. Future analysis on the flexibility of branches and its effect on wave damping is needed to implement this in the existing analytical formulations.

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