

# THE IMPACTS OF A MANGROVE PATCH ON WAVE PRESSURES ON THE SEA DIKE

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## ABSTRACT

Incorporating nature-based solutions with traditional hard coastal structures, serving as a hybrid coastal protection solution that encapsulates both hazard mitigation and ecological sustainability, is becoming popular. In this study, the non-hydrostatic model SWASH was employed to simulate the impacts of a mangrove patch on the sea dike. Through setting up comparative experiments with and without mangroves in front of the sea dike, the effects of mangroves on the wave height evolution in front of the sea dike and the variations of wave pressures on the sea dike were analyzed. The study indicates that the Goda formula cannot accurately estimate the impact loads on the vertical sea dike. Mangroves situated in front of the sea dike can significantly reduce the approached wave heights as well as the wave pressures on the sea dike. The maximum wave pressure on the vertical sea dike increases with the increase of wave steepness and Ursell number and decreases as the relative water depth increases.

## INTRODUCTION

Due to the changing climate and the rising sea level, coastal areas are becoming more vulnerable to coastal hazards. Sea dikes play a pivotal role in safeguarding coastal regions from the onslaught of tides and waves. However, the sea dikes would not function properly because of the ongoing rise in sea levels. To maintain the functionality of sea dikes, using nature-based solutions such as mangroves, as a kind of supplement to sea dikes, has been paid a lot of attention. Previous research into the impacts of wave pressures on sea dikes has primarily centered on the influences of wave parameters and structural characteristics of sea dikes on wave pressures. However, there remain limited studies concerning the specific impacts of mangroves on wave pressures on sea dikes. Hereinafter, we used the non-hydrostatic model SWASH, validated by experimental measurements, to simulate the interactions between waves, mangroves, and the sea dike. By setting up comparative tests with and without mangroves in front of the sea dike, the impacts of major factors on the wave heights in front of the sea dike and the wave pressures on the sea dike, such as wave steepness, Ursell number, and mangrove characteristics were analyzed.

## METHODOLOGY

This study employed the non-hydrostatic model SWASH to simulate the variations of wave pressures on the sea dike sheltered by mangroves. The model was validated by the experimental measurements from the wave flume tests at Hohai University. The empirical formula for the drag coefficient  $C_D$  of mangroves obtained from the laboratory experiments carried out by Zhang et al. (2023) was applied in the SWASH model to account for the loss of momentum induced by mangroves. The computational

domain is 15 m in length, with a horizontal grid resolution of 0.01 m, and comprises three vertical layers. The 2 m long mangrove patch is set from 0.6 m to 2.6 m in front of the vertical sea dike. The hydrodynamic parameters cover a wide range of wave conditions from shallow to deep water. The geometric scale was the same as the physical experiments, which was 1:10. In total, 97 tests were set up with the wave steepness ( $H/L$ ) ranging from 0.014 to 0.132, and Ursell number ( $Ur$ ) ranging from 0.73 to 26.33. The selected range of wave parameters includes conditions from non-breaking to breaking waves. Additionally, the selected range of mangrove characteristic parameters is consistent with the statistical characteristics of mangroves in the nature (Maza et al., 2021).

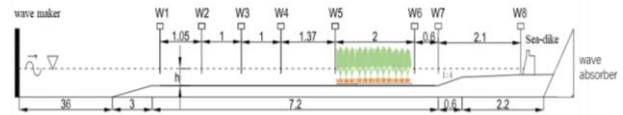


Figure 1. The setup of laboratory experiments

## RESULTS

The wave pressure time-series curve on the vertical sea dike was found presenting three types: quasi-standing wave loads, slightly breaking wave loads, and impact loads. The Goda formula provides a more precise estimate of the quasi-standing wave loads and the slightly breaking wave loads, but severely underestimates the impact loads. In addition to reducing the maximum wave pressure on the sea dike and the approached wave heights, the presence of mangroves in front of the sea dike can also reduce the frequency of impact loads on the sea dike. Nevertheless, under conditions when the wave height is quite high, the water depth is shallow, or the mangroves have a relatively small characteristic diameter, density, and width, the mangroves can lead to a slight increase of the wave heights in front of the sea dike. The maximum wave pressure on the vertical sea dike increases with the increase of the wave steepness, decreases with the increase of the relative water depth, and increases with the increase of the Ursell number. The submergence degree of the mangroves emerged as a key factor affecting the approached wave heights in front of the sea dike and the maximum wave pressure on the sea dike.

## REFERENCES

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