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LABORATORY STUDY ON WAVE OVERTOPPING ACROSS COASTAL DIKES WITH A VEGETATED FORESHORE

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ABSTRACT

Coastal dikes are commonly engineered to safeguard coastal areas from various coastal hazards. When incoming waves interact with these coastal dikes, wave overtopping frequently occurs if the storm wave's runup exceeds the dike's freeboard. This wave overtopping can lead to natural disasters, such as coastal flooding and damage to the protective layers of the dikes. Consequently, extensive research has been conducted on this phenomenon, assuming the absence of vegetation, as documented in EurOtop (2018). However, in many tidal flat regions, like the Yangtze River Delta, vegetation is prevalent and forms a vegetated foreshore alongside coastal dikes. It is widely acknowledged that a vegetated foreshore not only dissipates waves more effectively than a natural beach, as demonstrated in studies by Suzuki et al. (2019), but also reduces flow velocities, resulting in sediment accumulation over the vegetated area, as observed in research by Chen et al. (2012) and Hu et al. (2018). While increased wave dissipation due to vegetation may lead to reduced wave overtopping, there is currently limited research available that addresses the influence of vegetation on wave overtopping across coastal dikes.

This research conducted a series of laboratory experiments (as depicted in Figure 1) within the wave flume facility at Dalian University of Technology in China to assess how the vegetation impacts wave loading and overtopping across dikes. The wave flume dimensions are 60 meters in length, 4 meters in width, and 2.4 meters in depth, allowing for the simultaneous generation of solitary, regular, and irregular waves, etc. The experiments utilize a 1:30 slope, a 0.4-meter-high and 21-meter-length platform (including 15-meter of vegetation) to simulate the interaction between regular/irregular waves and vegetation and then measure wave loading, run-up and overtopping discharge after waves have passed through both the vegetation and the dike. Given the Froude scale of 1:3, the modelled Phragmites Australis (PA) in the experiment has the length of 60 cm, representing a 2 m tall live PA sampled in Chongming Dongtan, China. Finally, polytetrafluoroethylene (PTFE) tube was chosen to represent live PA, having comparable stiffness with live vegetation, to ensure that artificial vegetation has similar material properties and relative swaying motion.

This study will investigate the impact of various factors, including vegetation properties, hydrodynamic conditions (incident wave heights, wave periods and still water level of offshore) and geometry of the structure (vertical wall, absence/presence of sloping dikes on crown walls), on wave run-up, wave loading and overtopping at dikes. Preliminary results show that the vegetation can effectively decrease wave height, energy, force, and overtopping discharge. Given the limitations of existing cutting-edge formulas in the EurOtop (2018), our goal is to establish a set of relationships, that account for the interaction between wave conditions and the vegetation, to predict non-impulsive or impulsive overtopping for breakwaters in the presence of vegetation.

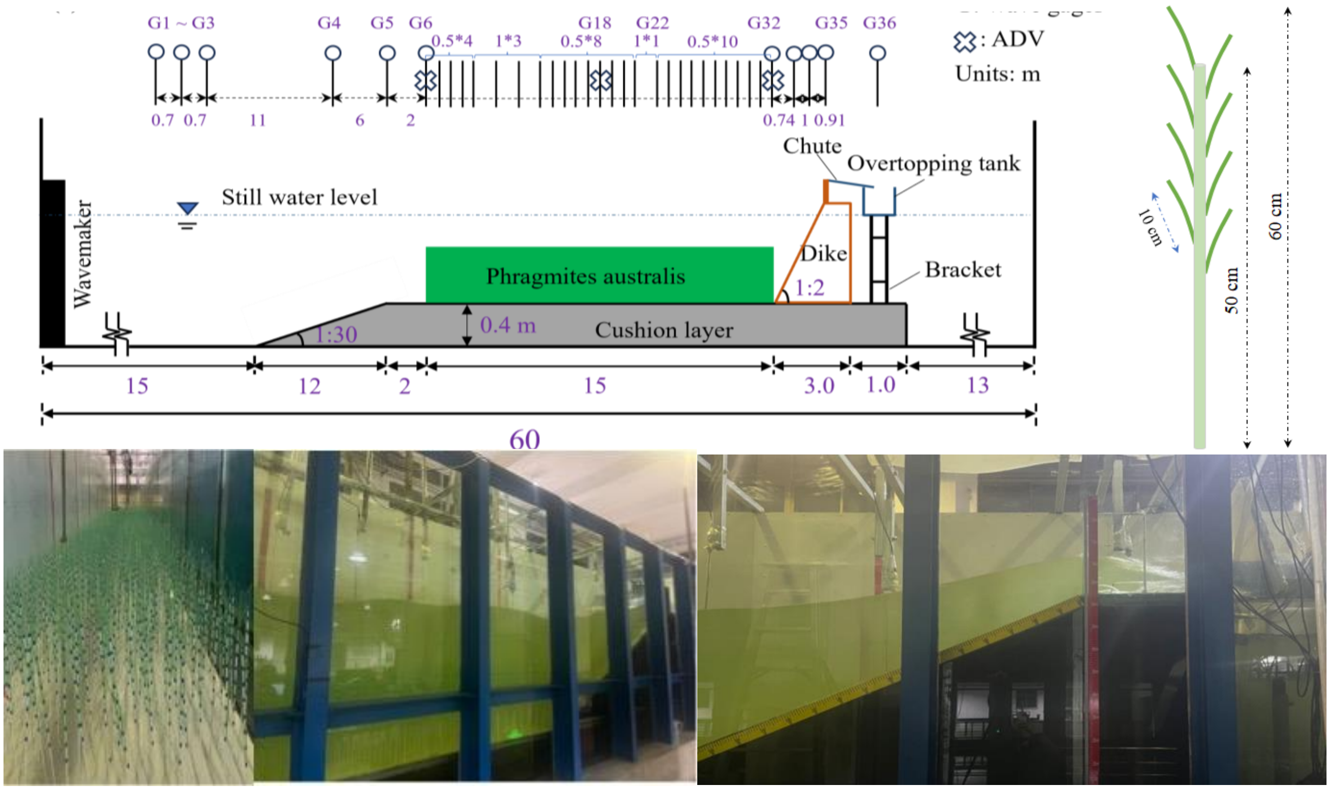

Figure 1. (top) Experimental setup (not to scale), (bottom) modelled vegetation and wave overtopping snapshot.

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