Physics-Based Wave Barrier Design for Storm Surge Protection

Chua, Marco (School: Stanton College Preparatory School)

Low-lying regions are inherently vulnerable to storm surge threats during a hurricane, yet many communities in those areas lack integrated coastal defense systems. Not all types of shorelines can accommodate currently available barriers, some of which are criticized for causing permanent spatial and visual intrusion and even downstream erosion. This study proposes a deployable wall-mounted wave barrier design whose effectiveness was evaluated and validated using applied physics principles and computational fluid dynamics modeling. It was assessed in its ability to reduce wave force and pressure. A full-scale section of the Memorial Park, a FEMA-designated high-risk flood zone that has repeatedly incurred damages from past hurricanes in Jacksonville, Florida, was used as a case study to demonstrate real-world application. The design features a symmetrical pattern that resembles wedges, which can disrupt motion before a wave crests, create turbulence, and break the wave before it crashes onshore. To supplement data from the CFD simulations and obtain further insight, a scaled-down 3D-printed prototype of the barrier was tested in a physical wave tank with a scale model of the Memorial Park's riverfront. Experimental results revealed that when installed, the barrier effectively reduces force and pressure. Compared to a flat seawall that faces the wave force head on, the barrier's surface redirects force, resulting in a lower area-weighted average static pressure. Its design lends greater structural stability and durability to the barrier, making it a viable and practical alternative for protecting vulnerable areas during hurricane season.

Awards Won: