Florida Department of Transportation Research

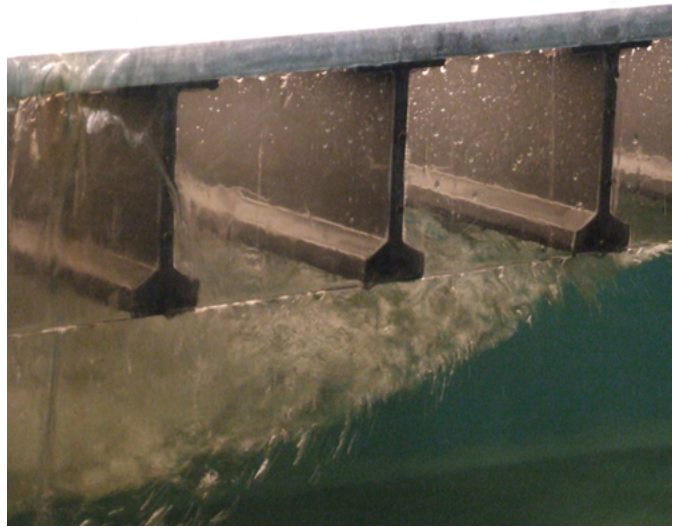
Wave Loading on Bridge Decks
BD545-58

In recent years, several major bridges along the Gulf coast were destroyed by hurricane-generated storm surge and wave loading. Hurricanes Ivan (2004) and Katrina (2005) alone destroyed six major bridges, including the I-10—Escambia Bay Bridge near Pensacola. Failures of this scale called for a better understanding of wave forces on horizontal structures and for improved methods for predicting the magnitude of these forces.

In general, waves present two kinds of forces to horizontal structures: a quasi-static wave action and a dynamic slamming force. Together, these forces damage bridges in several ways, such as failure of span tie-downs and span displacement or removal. Any movement of massive bridge spans can further damage support structures, rendering a bridge dangerous and unusable or resulting in collapse and destruction.

Researchers from the University of Florida (UF) were contracted to examine wave loading on bridge decks. They found much literature on horizontal wave loading on structures, but little on vertical forcing that applies to wave action. What they found had important limitations. For example, the action of waves on horizontal structures had been studied extensively for offshore settings, but these studies have limited application to bridge structures and wave types of coastal settings.

In their theoretical work, researchers extended existing models of wave force so that they could be applied to bridge superstructures and meteorological/oceanographic (met/ocean) conditions in coastal waters. Wave forces were divided broadly into a short duration, high frequency, slamming force and a slowly varying quasi-static force. The latter was further divided into a buoyancy force, a drag force, and an inertia force. Uniquely, this work included negative clearance heights, corresponding to submerged or partially submerged structures.



A wave passes under the model bridge structure.

The experimental phase was conducted in the 6′ × 6′ × 130′ wave tank at UF's Coastal Engineering Laboratory. Model structures progressed from a simple flat plate to model girder-type bridge spans with overhangs and rails, covering two of Florida's coastal bridge types and closely resembling a third. For each model, structure elevation, water depth, and wave parameters were varied to cover a wide range of conditions. Model structures were instrumented with three-component load cells and pressure transducers.

Empirical coefficients from wave tank tests were used with the theoretical model to predict wave loads on I-10—Escambia Bay Bridge spans. Cases in which wave loads exceeded structural resistance (dead weight plus tie-downs) and those in which it did not were both well predicted. This model was adopted by the American Association of State Highway and Transportation Officials (AASHTO) in numerical experiments covering a wide range of span types and met/ocean conditions, leading to the parametric equations in AASHTO's "Guide Specifications for Bridges Vulnerable to Coastal Storms."

Project Manager: Rick Renna, FDOT Roadway Design Office
Principal Investigator: D. Max Sheppard, University of Florida
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