Florida Department of Transportation Research

Validation and Implementation of Bridge Design Specifications for Barge Impact Loading

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With the amount of water-borne traffic and the number of bridges in Florida, collisions between vessels and bridges are inevitable. Few are as devastating as the 1980 collision of a freighter with the Sunshine Skyway Bridge, which took 35 lives and ended the bridge's service life, requiring construction of a new bridge. Nevertheless, every collision between a vessel and a bridge is dangerous for the vessel and its occupants, as well as the bridge and its many users. Collisions often lead to closures and expensive repairs.

This project is one in a series conducted by University of Florida (UF) researchers working with the Florida Department of Transportation (FDOT) to improve procedures for impact-resistant bridge design. Standard procedures for this were published over 20 years ago by AASHTO; since then, UF and FDOT have improved considerably upon them. The focus of this work was experimental validation of an improved UF/FDOT barge impact load-prediction model and implementation of numerous other UF/FDOT procedures into a comprehensive risk assessment methodology that can be readily adopted for use in bridge design.

To validate the UF/FDOT barge impact model, the researchers designed a reduced scale (40%) barge bow to be used in impact testing. Rather than the bow striking a structure, a novel test facility was created to deliver high energy impacts to the replicas, producing large-scale deformations. Impacts were delivered to the fixed barge replica by a pendulum and monitored with a variety of sensors and optical devices.

To "validate the validation," researchers conducted material testing on the steel materials from which the barge replicas were constructed. Because of the change of scale, it was important to understand how the behavior of the scale-model materials were related to the full-scale materials. Steel specimens were tested in uniaxial tension at strain rates covering seven orders

The replica barge is ready for experimental testing. The yellow and blue object just beyond the replica is the impact pendulum in its rest position.

of magnitude. Both conventional, quasi-static tests and pendulum-based high-rate testing were performed. Data from the material testing program were used to develop computer models of the barge replicas that were studies in finite element barge impact simulations.

The researchers developed a revised collision risk assessment methodology including various new UF/FDOT analysis procedures. The UF/FDOT and AASHTO procedures were applied to two real-world bridges, Florida's Bryant Grady Patton Bridge over Apalachicola Bay and Louisiana Highway Bridge 1 over Bayou Lafourche, and the results were compared. UF/FDOT predicted higher risk than AASHTO in these cases. However, terms in the AASHTO annual frequency of collapse expression associated with the probability of an impact event may, in fact, overpredict this probability, thereby inflating risk estimates.

This project showed that the procedure for bridge collision analysis and design developed by UF and FDOT are feasible, given modern programming and computing power. The new procedure has many advantages in its relationship to the real-world problem and the number of factors considered. Better procedures will lead to more accurate risk estimates and better bridge designs.

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