Florida Department of Transportation Research

Vessel Crushing and Structural Collapse Relationships for Bridge Design
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Accounting for potential waterway vessel collision is an integral component of structural design for any bridge spanning navigable waters. Collision-induced forces can be sufficient to cause collapse of piers or roadway spans. In bridge design, the probability of bridge collapse is currently estimated using an expression prescribed by the American Association of State Highway and Transportation Officials (AASHTO). However, due to the relative rarity of bridge collapses from vessel collision, the AASHTO expression was developed based on ship-to-ship collision data, rather than barge-to-bridge data. Also, the AASHTO provisions do not explicitly account for dynamic amplification of design forces.

In 2003, a barge tow struck a pier of the I-40 bridge near Webbers Falls, Oklahoma. A portion of the superstructure collapsed and 14 people were killed.

Researchers at the University of Florida, Department of Civil and Coastal Engineering, recently developed revised probability-of-collapse (PC) expressions that bridge designers can use to estimate the probability that a bridge will collapse after being struck by an errant barge. Such expressions form a critical component of structural risk assessment as it pertains to vessel collision design of bridges. The revised PC expressions were developed using rational structural reliability analyses and permit designers to estimate probability of bridge collapse using only results from a single non-probabilistic structural analysis.

For the bridges considered in this study, the research results revealed that PC values predicted using the newly developed expressions differ from AASHTO expressions. For some bridges, the revised PC expressions predict higher probabilities than AASHTO, while in other cases the new expressions predict lower values. The researchers also found that barge impact forces are strongly dependent on angle of impact when impact occurs on flat pier surfaces. Consequently, they developed revised barge force-deformation relationships that probabilistically account for the influence of impact angle on forces generated during impact.

The structural collapse relationships developed as part of the study constitute a practical tool for conducting barge impact risk assessment for new bridge designs and existing structures. The revised expressions provide more realistic probability of collapse estimates than the existing AASHTO procedure. Researchers recommend implementation of the expressions to produce a more uniform distribution of structural safety among newly designed bridges. They also note that employing the revised barge force-deformation model within an impact load calculation process will lead to significant reductions in design forces, and therefore more economical designs, in bridges that utilize wide rectangular pier columns or pile caps.

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