Florida Department of Transportation Research

A Static Analysis Method for Barge-Impact Design of Bridges with Consideration of Dynamic Amplification

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Several hundred Florida bridges span waterways deep enough for barge traffic. To ensure a bridge is capable of withstanding the potential impact of a barge collision, engineers use design specifications recommended by the American Association of State Highway and Transportation Officials (AASHTO). The AASHTO design provisions employ a static analysis approach, primarily taking into account the weight of the components at rest.

However, barge collisions are fundamentally dynamic in nature, given that impacts occur when a moving barge, possessing kinetic energy, strikes a deformable bridge structure such as a pier. Kinetic energy affects the magnitude of the loads generated, and the traditional static analysis method fails to capture these amplification effects.

To identify sources of dynamic amplification and quantify the degree to which these effects increase design forces, researchers from the University of Florida analyzed bridges throughout the state under both static and dynamic barge impact conditions.

The study uncovered two primary sources of amplification of pier forces: superstructure inertial restraint and momentum driven sway. Both of these mechanisms were attributable to the mass of the superstructure overlying an impacted pier.

Researchers used a time-history analysis approach to simulate forces from an impact event and determine how a structure responds during and after an impact. Superstructure stiffness and mass (inertia) acted to resist pier motion upon impact. During the later stage of the collision event, the superstructure accelerated and developed momentum.

A moving barge strikes a bridge pier during a colllision experiment.

These dynamic influences are inherently difficult to capture using existing static analysis procedures. With an improved understanding of dynamic amplification effects, researchers developed a new static analysis method that emulates superstructure inertial restraint.

The innovative technique, called static bracketed impact analysis (SBIA), uses two static analysis load cases to envelop – or bracket – pier design forces in such a manner to produce reasonably conservative estimates of dynamic amplification effects. The first load case addresses inertial resistance. The second load case excludes the inertial load and provides a reliable means of quantifying maximum foundation forces.

The SBIA method developed in this study is simple to use, conservative, and capable of accounting for dynamic amplification. An ideal bridge design process might involve the use of SBIA for preliminary design, followed by more refined time-history analysis to maximize safety and minimize costs.

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