Project Summary

Texas Department of Transportation

9-4973: Guidelines for Designing Bridge Piers and Abutments for Vehicle Collisions

Background

Load and Resistance Factor Design (LRFD) Bridge Design Specifications, published by the American Association of State Highway and Transportation Officials (AASHTO), contains detailed requirements for protecting bridge piers from vehicle collisions and designing piers to resist collision loads. Supporting documentation for design requirements, both the applicability and magnitude of design force, is not extensive.

Two issues exist:
1. What risks warrant application of the requirements?
2. Is the magnitude of the design force appropriate?

80,000-lb Tractor-Trailer Impacting Simulated Bridge Pier

What the Researchers Did

The researchers performed a study consisting of the following tasks:

Phase 1:
- Literature review,
- Computer simulations of vehicle/bridge column and abutment collisions,
- Accident survey and analysis study,
- Development of a risk analysis methodology for vehicle/bridge column and abutment collisions (analogous to AASHTO *LRFD* vessel impact requirements),
- Detailed justification and work plan for research to be conducted under Phase 2 of the project, and
- Arrangement for facilities and hosting of a meeting to present Phase 1 results to project participants from other state departments of transportation.

Phase 2:
- Two full-scale crash tests involving an 80,000-lb tractor-trailer impacting an instrumented bridge pier, and
- Final report describing project activities and findings.

Research Performed by:

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Project Completed: 2-28-10

What They Found

Researchers investigated and reported on 19 accidents involving trucks colliding with bridge piers. They found that several accidents resulted in partial or complete structural failure of the pier. Failure mechanisms consisted of two shear failure planes – one extending upward from the applied load at approximately 45 degrees and the other extending downward at approximately 45 degrees.

Finite element analyses of truck collisions with bridge piers were performed using the LS-DYNA computer program. Parameters investigated included type of truck (65,000-lb single-unit truck (SUT) and 80,000-lb tractor-trailer), type of cargo (deformable and rigid), impact speed (40, 50, and 60 mph), and diameter of pier (24, 36, and 48 inches). The analyses indicated that, within the range of parameters studied, forces imposed on a pier can be much higher than 400 kips and that the magnitude of force is highly dependent on cargo type.

A methodology for estimating the risk for a heavy vehicle to leave the travel-way and hit a bridge pier was developed. Separate models were developed for undivided and divided roads, as well for straight tangent sections and horizontal curves. Two examples are provided in the full report to describe how the methodology can be used for individual sites and corridor studies.

An instrumented, simulated bridge pier was constructed and two full-scale collisions with an 80,000-lb van-type tractor-trailer were performed on it. The trailer was ballasted with bags of sand on pallets. Force-versus-time data were obtained from load cells that supported the simulated pier. The load cell data, when filtered with a 0.050-sec moving average, indicated an equivalent static design force of 400 kips. Refined analyses of the data indicated that an equivalent static design force at the interface of the truck and pier should be approximately 600 kips.

What This Means

This project developed information that indicates revisions should be made to selected sections of the AASHTO *LRFD Bridge Design Specifications*. The recommended revisions for submittal to the appropriate AASHTO subcommittees for consideration are as follows:

- Incorporate crash risk analysis methodology into AASHTO *LRFD Bridge Design Specifications*.
- Change equivalent static force from 400 kips to 600 kips.
- Change direction of applied force from “any direction” to “zero to 15 degrees to the edge of the pavement.”
- Change height of force from 4.0 ft above ground to 5.0 ft above ground.

For More Information:

9-4973 Analysis Of Large Truck Collisions With Bridge Piers: Phase 1. Report Of Guidelines For Designing Bridge Piers And Abutments For Vehicle Collisions

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