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VEHICLE COLLISION WITH BRIDGE PIERS

PROBLEM STATEMENT

Vehicle/pier collisions can have serious implications in terms of loss of human lives and damage to the transportation system and economy. The most recent event that demonstrates the extent of this problem is the failure that occurred on May 23, 2003 in Big Springs, Nebraska. One person was killed and Memorial Day traffic was severely disrupted on the busy I-80 route when a vulnerable bridge pier was struck by an errant truck. Although the current AASHTO-LRFD (1998) has provisions to address such events, the specifications have a number of significant limitations, including the following: (1) the design collision force is not specified as a function of the design speed of the adjacent roadway or the vehicle characteristics, (2) dynamic interaction between the colliding vehicle and the bridge structure is not recognized, and (3) there are no guidelines on how to detail a vulnerable member to ensure that it will survive a severe impact situation (i.e., with a specific structural performance in mind). Given these issues, investigation of the parameters influencing vehicle-bridge collisions is warranted.

OBJECTIVES

The overall goal of this research is to use state-of-the-art numerical simulation techniques to develop a better understand of the vehicle/pier collision process and to provide information that will be useful for the future development of comprehensive design guidelines for vehicle collision. Specifically, the three main objectives include the following:

- identify software that can be used in conducting the required simulations
- develop models of vehicles and bridge piers that can be used to represent feasible crash scenarios
- achieve a good understanding of the collision process and use this information to critique current design guidelines.

FINDINGS AND CONCLUSIONS

This project documents three recent accidental collisions between heavy vehicles and bridge piers that occurred with catastrophic consequences and related loss of life. Researchers used inelastic transient finite element simulations to investigate the structural demands generated during such events. In this study, researchers utilized vehicle models developed by FHWA for safety/crashworthiness: a 14-kN Chevy truck (representing lights trucks) and a 66-kN Ford truck (representing medium weight trucks). Researchers had hoped to use a third model to represent the heaviest permissible trucks, i.e., a 360-kN tractor trailer model. However, as of the completion of this research, that model was still unavailable.

The two truck models were crashed at various approach speeds into finite element models of two bridge piers with different structural characteristics. Various parameters were computed from the simulations, including stress and strain at key locations; pier, foundation and superstructure deformations; and transient impact forces. Since the peak transient forces occur for a very short duration, during which the pier does not have time to respond, equivalent static forces are computed as a more appropriate measure of the design structural demand. The calculated forces are used to critique the AASHTO-LRFD vehicle collision provisions.

Although physical vehicle-pier impact tests were not carried out to verify the accuracy of the simulations, a variety of exercises were conducted to provide confidence in the analysis results. These exercises included reviewing previously published verification studies involving the 14-kN truck, mesh refinement studies, energy balance audits, impulse/momentum conservation checks, monitoring of hourglass control energy during the simulations, and comparison of pertinent results to data from truck/bollard collision tests.

The vehicle/pier crash simulations conducted as part of this research have shed light on the demands created during the collision process. The results show that the computed equivalent static forces could be significantly higher than the AASHTO-LRFD design force for a number of simulations involving both light and medium trucks. These results imply that the AASHTO-LRFD design provisions could be unconservative for possible crash scenarios. There is also a concern that trucks heavier than those considered in this project, such as tractor trailers, could possibly generate even higher demands.

BENEFITS

This research has resulted in an improved understanding of collisions between vehicles and bridge piers, which is essential for the future development of improved design specifications. In the long run, studies such these will lead to better vehicle and bridge designs that can reduce the potential for serious structural damage as well as the potential for fatal injury during vehicle-bridge collisions.

This project was conducted by Sherif El-Tawil, Ph.D, P.E., of the University of Michigan, at the Center for Advanced Transportation Systems Simulation, University of Central Florida. For more information, contact Marc Ansley, at (850) 414-4291, marc.ansley@dot.state.fl.us .