Summary of Final Report, BD493
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ANALYTICAL AND EXPERIMENTAL EVALUATION OF EXISTING FLORIDA DOT BRIDGES

PROBLEM STATEMENT

Evaluation of existing structures is critical for efficient management of transportation facilities, especially bridges. Knowledge of actual load effects and structure capacity can be very helpful for the determination of the load carrying capacity and the condition of structures. It can be useful for making management decisions, such as establishing permissible weight limits, and it can have important economical and safety implications.

Many bridges are difficult (if not impossible) to evaluate using traditional inspection methods and simplified static analysis. In particular, the dynamic nature of live loads and bridge-vehicle interaction is not sufficiently considered in the design process. Impact factors suggested by bridge design codes usually lead to conservative solutions, especially for overloaded vehicles. The increasing computational capability of computers and the rapid development of commercial finite element programs allow for more advanced, numerical, 3-D dynamic analysis of bridge structures. It is now possible to develop detailed models of bridges containing a large number of finite elements with different levels of sophistication for suspension systems, kinetic characteristics of vehicle components, and wheel models. Application of these models would allow for rigorous investigation of the vehicle-bridge interaction and evaluation of the actual impact factors. Full-scale bridge tests are often carried out not only to provide the real information on the dynamic response of bridges, but also to validate computational dynamic analyses.

OBJECTIVES

The main objective of the project was to assess the dynamic response of short- and medium-span highway bridges. Emphasis was placed on the determination of actual impact factors. The study consisted of analytical work validated by a field test conducted by the FDOT Structures Lab on the selected bridge (#500133) over Mosquito Creek. Researchers developed finite element models for four selected FDOT bridges and four heavy vehicles. Vehicle models consisted of a tractor-trailer and three different cranes with rotating pneumatic wheels, and suspension systems with simplified models of springs and shock absorbers. A complete truck and bridge system containing almost 500,000 finite elements allowed for computer analyses of dynamic interaction between a passing truck and the bridge structure. Experimental data was used for finite element model validation.

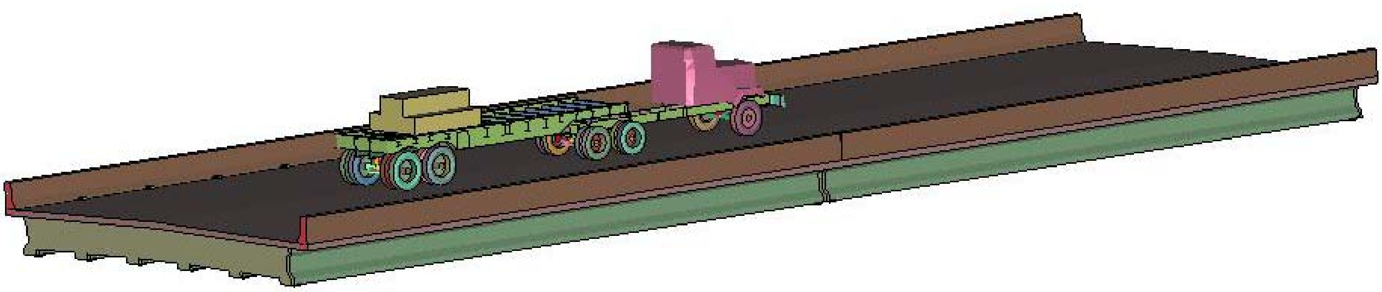
FINDINGS AND CONCLUSIONS

The validated FE models were used to simulate the vehicle-bridge interaction. A total of 32 cases with different vehicle and bridge combinations were investigated. These results will assist the FDOT Maintenance Office with issuing overweight permits. The experimental and numerical data from this research also showed that the most significant dynamic effects expressed by the impact factor resulted from geometric surface imperfections (a deck threshold and a bridge approach depression) even though the vehicle suspension, its speed, the bridge span length, and the position of the loading vehicle also influenced the impact factor.

Higher vehicle speeds (greater than 45 mph) can trigger the bouncing of loads initiated even by small road surface imperfections (e.g., 15 mm bridge deck threshold). Such a hammering effect results in much higher impact factors than those listed in the AASHTO code. A speed reduction to 35 mph for overloaded vehicles crossing a bridge can significantly reduce dynamic effects. Overweight trucks should be restricted to the right traffic lane. The study has shown that dynamic stresses in girders can be larger if a vehicle is crossing the bridge close to the centerline of the deck. Inexpensive maintenance tasks, such as elimination of bridge deck thresholds and bridge approach depressions, are cost effective remedies that can result in considerably reduced dynamic impact factors.

BENEFITS

The Maintenance Office of the Florida Department of Transportation is charged with the mission of supporting and enhancing truck mobility while preserving transportation infrastructure. This mission challenges the Department to allow larger and heavier trucks on Florida highways and bridges without compromising bridge safety. This challenge becomes even more complex if time for making these decisions is limited. Quick decisions made by the FDOT require validated and accurate information on maximum dynamic loading (impact factors) imposed by several types of moving vehicles on a wide variety of Florida bridges. The results of this research will help the FDOT Maintenance Office estimate the dynamic effects and will make the permit-issuing process more dependable and accurate. This study serves as an important prelude to a follow-up project which focuses on the surface imperfection effect on dynamic impact factors. The developed and validated finite element models of the bridges and the vehicles are easy to modify to cover new vehicle and bridge types, and they can now be used for other projects of interest to the FDOT.



This research project was conducted by Jerry Wekezer, Ph.D., P.E., at the Crashworthiness and Impact Analysis Laboratory, FAMU-FSU College of Engineering. For more information, contact Jean Ducher, Project Manager, at (850) 410-5757, jean.ducher@dot.state.fl.us.