Connecticut's Bridge Monitoring Program

Making Important Connections Last

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Through a cooperative research program, the Connecticut Department of Transportation and the University of Connecticut are utilizing several monitoring systems to continuously monitor the behavior of in-service highway bridges in both temporary and continuous applications. Response data collected in the past with temporary systems have been used successfully to guide bridge repair decisions, reduce project scopes, and save money. Response data collected with permanently installed systems will be used to define healthy behavior for in-service bridges and to serve as the basis for determining bridge integrity on a continuous basis.

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Problem

Transportation authorities are continually challenged to provide and maintain a safe and efficient highway network. Not only are bridges an integral part of the network, they also represent a multibillion dollar investment. To meet this challenge and safeguard this investment, transportation authorities need to understand completely the condition and behavior of the bridge structures, so that the bridges can remain open to traffic, be resistant to the elements, and be undaunted by the millions of loading cycles per year—all with minimal maintenance expense.

Realistically, the high cost of maintenance—often exacerbated by the budget-driven policies of bridge owners—frequently leads to the deferment of routine bridge repairs and preservation measures. These policies can contribute to an occasional bridge failure, which is completely unacceptable and forces more costly actions.

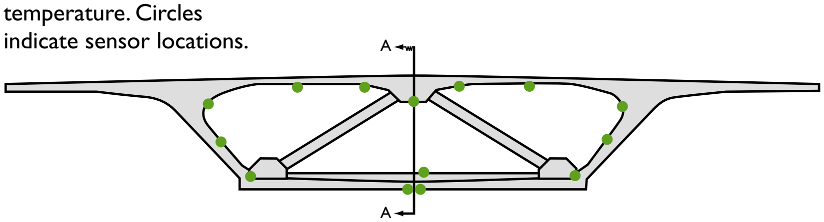
To manage bridges effectively, more needs to be done to assess the day-to-day and long-term condition and behavior of in-service bridges, so that preventive measures can be taken, and deterioration rates can be better understood.

Solution

The Federal Highway Administration and the Connecticut Department of Transportation (DOT) are sponsoring research on the use of state-of-the-art monitoring systems to determine the behavior and condition of in-service highway bridges and to promote a proactive response to maintenance and inspection needs. Two objectives of this research are to provide a reliable supplement to current inspection procedures and to improve the understanding of the behavior of bridges. The scope of this ongoing study includes

- The application of temporary instrumentation to determine in-service behavior and to justify rehabilitation and repair plans, and
- The installation of continuous monitoring systems on bridges of various type, size, and vintage, to record long-term behavior and to develop global condition assessment guidelines.

FIGURE 1 Cross-section of bridge being monitored continuously for temperature. Circles indicate sensor locations.



Application

A monitoring system can determine stress levels in steel members or bridge components and can identify the cause of cracking or fatigue categories applicable to the structure. Temporary monitoring on several large steel bridges has addressed such problems as fatigue cracking in diaphragm connections, cracked secondary connections, main-girder cracking, counterweight support capacity, load rating, overload influence, drive mechanism stresses, and movable bridge member stresses.

In general, the findings have shown that the ability to monitor an in-service bridge on a temporary basis is invaluable for determining specific, economical, and effective repair and rehabilitation plans. Accordingly, continuous monitoring would have a positive influence on the design and management of the entire bridge network.

Continuous monitoring systems have been installed on

- A curved, three-span, continuous cast-in-place concrete multibox-girder bridge;
- A ten-span, continuous precast concrete single-cell girder bridge; and

◆ A curved, three-span, continuous steel dual-box girder bridge.

Each system has unique features conducive to monitoring the aspects of each bridge. Sensors—which include tiltmeters, accelerometers, strain gauges, and thermocouples—measure tilt, vibration, strain, and temperature at various locations throughout the structures. The maximum number of sensors on any one bridge is 52—which includes all of the previously mentioned types—and the minimum number is 14 thermocouples. The sensor configuration is based on the needs of the particular bridge.

Bridges scheduled to have continuous monitoring systems installed in 2002–2003 include typical rolled-beam concrete-deck bridges, a multispan continuous bridge, a simple span bridge regularly subjected to heavy loads, a typical precast concrete girder bridge, and a large-deck truss bridge with a suspended span. Additional sensor types planned for these and other bridges include a linear variable-distance transducer to measure the movement of expansion bearings and state-of-the-art strain-monitoring sensors.

Benefits

The benefits of portable monitoring are numerous and quantifiable. Connecticut DOT has decided on rehabilitation options for several bridges from the data collected with the portable monitoring systems (see Table 1).

Through revised rehabilitation plans and in-house data collection, the temporary monitoring has saved more than $3 million since 1997. For example, field data were collected from a steel girder bridge that had cracks in connection angles. Preliminary plans had called for the replacement of approximately 900 angles; however, monitoring showed that was not necessary. The duration of the project was decreased by one year, and the revised plan saved $250,000. On another steel bridge, the number of diaphragms to be replaced was reduced by two-thirds, saving close to $2 million.

Safety benefits were demonstrated by a study of a counterweight hanger on a movable bridge. The analysis of field measurements showed that the hanger was inadequate and strengthening was required. Repairs were made in time to maintain the functionality of the bridge without compromising the safety of the public.

More benefits of continuous monitoring are forthcoming. A system will be installed on a new, major bridge on the historic Merritt Parkway in southwestern Connecticut. The bridge will be the first in the state—and one of the few in the country—with a monitoring system included in the original construction documents. The system will monitor continuously strain, tilt, vibration, and expansion.

TABLE 1 Portable Monitoring System Applications

Town	*Bridge type*	*Problem/Concern*	*Outcome*	*Benefit ($)*
Bridgeport	Steel bridge on I-95	Cracked connections	Fewer repairs	$2,000,000
Wethersfield	Steel bridge	Cracked connections	Repair not required	$250,000
New Haven	Steel moveable	Counterweight hanger	Immediate repair verified	Safety
Norwalk	Steel bridge on Rt. 7	Fatigue cracking	Repair not required	$50,000
Westport	Steel bridge on Parkway	Fatigue cracking	Repair not required	$50,000
Trumbull	Steel bridge	Girder strength	Repair not required	$25,000
Seymour	Steel bridge	Cracked connections	Repair not required	$250,000*
North Haven	Steel bridge	Cracked girders	Repair not required	$10,000
South Norwalk	Bascule bridge	Drive mechanism study	Outside consultant not required	$10,000
Mystic	Bascule bridge	Member forces	Continuing	$25,000
East Haddam	Swing bridge	Member forces	Outside consultant not required	$40,000

**Length of project was reduced by one year.*

Ultimately, continuous monitoring will indicate a bridge's health or integrity. This type of monitoring has the potential to save human life and a tremendous amount of money, considering the number of people who use bridges every day and the volume of commerce that relies on the highway network. Other long-term benefits will be the refinement of design criteria from actual behavior, the development of more accurate deterioration rates, and the availability of more realistic data for bridge management decisions.

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EDITOR'S NOTE: Appreciation is expressed to David Beal, Transportation Research Board, for his efforts in developing this article.

Suggestions for "Research Pays Off" topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001 (telephone 202-334-2952, e-mail gjayapra@nas. edu).