2009-29TS
Published February 2010

RESEARCH
SERVICES SECTION

TECHNICAL SUMMARY

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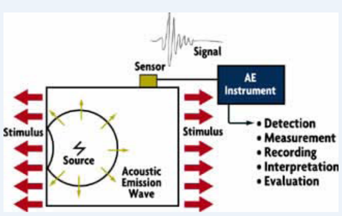
PROJECT COST:
$143,160



Acoustic instrumentation (schematized above) is just one of many systems available to bridge owners for monitoring the structural health of bridges.

Bridge Health Monitoring and Inspection: A Survey of Methods

What Was the Need?

In the wake of the I-35W bridge collapse in August 2007, bridge designers, engineers and caretakers have intensified their interest in techniques and equipment for monitoring bridge health that complement standard inspections. Aging infrastructure also requires more frequent and careful monitoring to assure both public safety and proper performance. Techniques and applications for remote monitoring vary widely and address both short-term changes in bridge structure and the assessment of long-term performance. Mn/DOT has funded projects examining a variety of monitoring techniques including the measurement of distortional fatigue, wind-induced vibrations and soil pressures.

Increasing the frequency of hands-on inspection of Minnesota's hundreds of aging bridges is both costly and an impractical burden for bridge engineers and inspectors. Many companies sell products and services that can aid bridge engineers in assessing the health of bridges more thoroughly and more frequently. However, in the face of the daunting number and variety of products and applications available, an obstacle for the adoption of these technologies is the absence of comprehensive criteria for evaluating and selecting the technologies.

What Was Our Goal?

The objectives of this project were to generate criteria for the evaluation and selection of bridge monitoring technologies and systems, and to develop a program to aid engineers in assessing which commercially available bridge monitoring technologies are most appropriate for a given site.

What Did We Do?

Bridge health monitoring instrumentation and techniques vary according to the time frame and physical scale of the monitoring.

- The monitoring time frame may be more or less than a year (classified as long term or short term) or part of a regularly scheduled inspection of components. Regular monitoring tracks the time development of particular measures such as the growth of known cracks or the spread of known corrosion. Early warning systems for bridge owners or collapse warning systems for motorists would provide notification if measured parameters exceed predetermined ranges.
- The physical scale of monitoring can vary from the examination of specific locations in the bridge (for instance, known cracks or corrosion at specific locations) to monitoring the motion and integrity of individual structural members (such as girders or decks), to global monitoring of the entire bridge structure. Instrumentation varies based upon the application. Some examples of different types of scans are acoustic emission, vibrating wire strain gauges, 3-D laser scanning, ground penetrating radar, fiber optic sensors and macrocell corrosion rate sensors.

Researchers worked with staff from Mn/DOT's Office of Bridges and Structures to develop a clear and detailed understanding of their inspection and monitoring needs, leading to the development of robust criteria for selection and evaluation of monitoring technologies. Researchers developed a questionnaire for monitoring system vendors to characterize the different types of systems and services that are commercially available. The nature and time frame of the monitoring, the specific parameters measured and the expected application of the acquired information formed essential parts of this survey.

continued

"This research gave us a process and a tool to make more informed decisions about monitoring products without needing a bevy of experts in the bridge office."

–Gary Peterson,
Mn/DOT Assistant Bridge Design Engineer (retired)

"Monitoring systems that can automatically and reliably warn the owner when failure is imminent have yet to be developed and may become a very useful tool in the future."

–Arturo Schultz,
Professor, University of Minnesota Department of Civil Engineering

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The collapse of the I-35W bridge (left) in August 2007 intensified the interest in bridge health monitoring. In this project, researchers helped Mn/DOT staff evaluate the instrumentation proposed for monitoring the new St. Anthony Falls Bridge (right), which opened in September 2008.

Overall, the questionnaire sought information on the major uses, components and goals of the equipment and software that define a given vendor's monitoring system.

Questionnaires were sent to 72 vendors, and 38 completed them. Researchers focused on vendors that offer complete monitoring systems, which are composed of a control unit, sensors, communication and software.

Based on the selection criteria, researchers then developed a spreadsheet-based tool, implemented in Microsoft Excel, to help bridge owners determine which companies offer systems that fit their particular needs, matching each owner's desires to company specifics that were returned in the questionnaire and listing the companies that best fit the owner's needs. The evaluation of the products and services offered is left to the bridge owner.

What Did We Learn?

While many products are available, most systems would serve as components of a global monitoring strategy that needs to be developed independently. Specific monitoring needs like crack width and girder strain are addressed, but judgments regarding bridge health require further evaluation of the output from these monitoring systems. In particular, reliable, robust systems for warning of imminent collapse have yet to be developed and will likely be a system composed of the pieces that are currently available.

What's Next?

The database is being used to aid in the selection of monitoring equipment. The researchers have since participated in the selection and deployment of strain-gauge monitoring on the Wakota Bridge in the southeast Minneapolis/St. Paul area.

This Technical Summary pertains to Report 2009-29, "Bridge Health Monitoring and Inspections Systems—A Survey of Methods," published September 2009. The full report can be accessed at http://www.lrrb.org/PDF/200929.pdf.