Implementation of Structural Health Monitoring System

tech transfer summary

Given the maturity and effectiveness of the structural health monitoring system for bridges developed and validated over a significant time period in Iowa and other states, the timing may be favorable for the Iowa DOT to consider implementing a comprehensive structural health monitoring system program.

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RESEARCH PROJECT TITLE
Implementation of Structural Health Monitoring System

SPONSORS
Iowa Department of Transportation
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The Bridge Engineering Center (BEC) is part of the Institute for Transportation (InTrans) at Iowa State University. The mission of the BEC is to conduct research on bridge technologies to help bridge designers/owners design, build, and maintain long-lasting bridges.

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Overall Goals

- Demonstrate the usefulness of Iowa's custom-built structural health monitoring (SHM) system on the management of bridges
- Document past and current research and the state-of-the-state related to the SHM of bridges in Iowa
- Outline what is needed to go forward in implementing a long-term SHM program using the system developed and validated to date

Background

The Iowa Department of Transportation (DOT) Office of Bridges and Structures continues to provide safe travel conditions on bridges in the state while maintaining critical infrastructure assets. Beginning about 20 years ago, the Bridge Engineering Center (BEC) at Iowa State University started working toward developing and evolving an autonomous SHM system to assess the safety of bridge structures and to determine the remaining life of bridges.

SHM provides an effective and efficient process to maintain the bridge inventory. The evolution of the SHM system includes monitoring of more than 15 bridges, with additional bridge projects in progress and planned.

While there are other structural health processing systems in the US, we believe our SHM system is the most comprehensive and effective system to date. An important aspect of the success of the SHM system is due to the strong partnership between the Iowa DOT and the BEC.

I-80 WB Bridge over Cherry Creek near Newton, Iowa

Project Description

These were the four tasks for this particular project:

- Design, configure, install, and calibrate an SHM system on the eastbound (EB) I-80 Bridge over Cherry Creek
- Calibrate the SHM system on the Iowa Falls Bridge
- Monitor trained SHM sites
- Document and disseminate information, including recommendations for long-term SHM implementation

Key Findings, Recommendations, and Implementation Benefits

Integration of SHM Data into a Holistic Bridge Preservation Plan

In general, it is already clear that bridge data collected from the SHM system has provided valuable information and insights. Bridge engineers will be able to develop ideas on how to use the data to understand bridge performance.

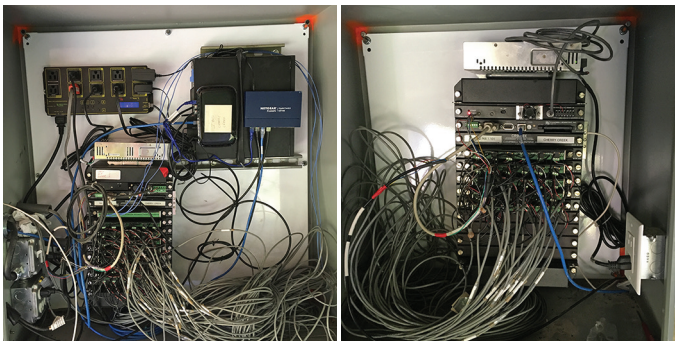
For example, the SHM system data could provide insights into the real-time data versus the actual design process used. Critical elements on a bridge could be evaluated using real-time data versus expected design behavior, thus gaining a better perspective. Furthermore, the real-time data can identify anomalies on the bridge (such as fatigue cracks or a bad bridge bearing), and alert bridge engineers that the bridge is not performing correctly.

Once a repair is made for an anomalous problem, subsequent real-time data can determine if the repair is effective. An important aspect of managing bridge performance (usually done by inspections of bridges every several years) is to develop a bridge rating to assure safety. Using the SHM system data, the bridge rating is continuously collected.

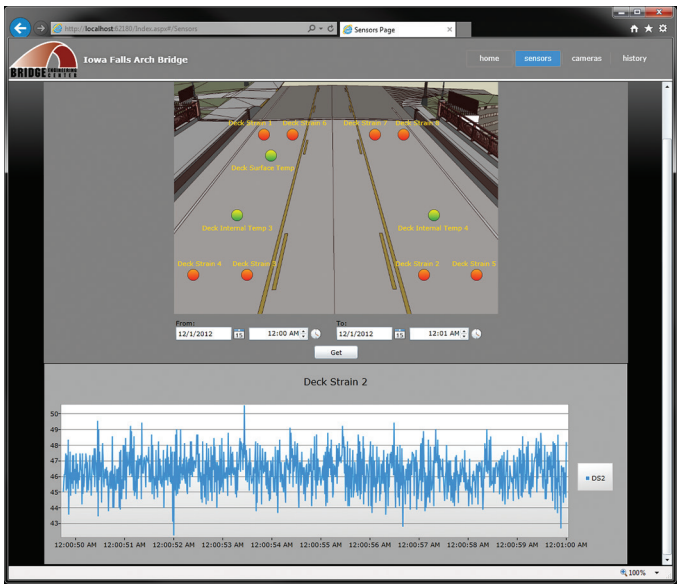
A more specific and exhaustive list of the information that the SHM system data can provide to bridge engineers is included in the final report for this project. An appendix of the report includes an example of representative data that may be produced by the SHM system for use by Iowa DOT bridge engineers to better understand a bridge's performance.

Establishment of a Bridge Monitoring "Command Center"

A focus on data interpretation and quick response to bridge issues is important for a successful program. One possible format might be to create a new focus area (or similar) within the Iowa DOT.



SHM hardware for the I-80 WB Bridge over Cherry Creek including a high-speed data logger, desktop-class PC (to control data acquisition), Ethernet switch and/or router, 4G cellular modem, internet-based camera, land line power source, and workstation-class PC (for data analysis and strain and temperature sensors)



Real-time strain in the concrete bridge deck at one location from Iowa Falls Bridge data website sensor timespan results

Solar panels providing power to bridge sensors (left) and battery storage cabinets under the bridge (right) for the I-80 EB Bridge over Sugar Creek in Iowa

Field site with solar power (top) for typical SHM system on the I-280 EB Bridge (bottom) over US 67 near Milan, Illinois

Implementation Readiness

The Iowa DOT has already invested in implementing an SHM system for their bridges. There are multiple bridges in Iowa that have been "fitted" with the system, and there are considerable data collected to better identify bridge performance.

Given the maturity and effectiveness of the structural health monitoring system for bridges developed and validated over a significant time period in Iowa and other states to date, the timing may be favorable for the Iowa DOT to consider implementing a long-term SHM system program.

The most significant decisions for the Iowa DOT include developing a comprehensive implementation process, including staffing. Additional needs would require investment in hardware and software, as well as developing an overall effective process to utilize the SHM system. These are outlined in more detail in the last chapter of the final report for this project.