Evaluation of a Bridge Constructed with High-Performance Steel

tech transfer summary

HPS can help reduce bridge maintenance costs and extend useful life. Well-developed SHM system has the potential to help determine bridge maintenance and replacement schedules.

Objectives

- Evaluate the use of high-performance steel in bridge applications.
- Use innovative structural health monitoring techniques to monitor bridge performance continuously and to develop expertise in the structural health monitoring in Iowa.

Problem Statement

Of the approximately 25,000 bridges in Iowa, 28% are classified as structurally deficient, functionally obsolete, or both. Because many Iowa bridges require repair or replacement with a relatively limited funding base, there is a need to develop new bridge materials that may lead to longer life spans and reduced life-cycle costs. In addition, new and effective methods for determining the condition of structures are needed to identify when the useful life has expired or other maintenance is needed.

Technology Description

Due to its unique alloy blend, high-performance steel (HPS) has been shown to have improved weldability, weathering capabilities, and fracture toughness than conventional structural steels. Since the development of HPS in the mid-1990s, numerous bridges using HPS girders have been constructed, and many have been economically built.

The East 12th Street Bridge, which replaced a deteriorated box girder bridge, is Iowa's first bridge constructed using HPS girders. The new structure is a two-span bridge that crosses I-235 in Des Moines, Iowa, providing one lane of traffic in each direction.

A remote, continuous, fiber-optic based structural health monitoring (SHM) system for the bridge was developed using off-the-shelf technologies. In the system, sensors strategically located on the bridge collect raw strain data and then transfer the data via wireless communication to a gateway system at a nearby secure facility. The data are integrated and converted to text files before being uploaded automatically to a website that provides live strain data and a live video stream. A data storage/processing system at the Bridge Engineering Center in Ames, Iowa, permanently stores and processes the data files. Several processes are performed to check the overall system's operation, eliminate temperature effects from the complete strain record, compute the global behavior of the bridge, and count strain cycles at the various sensor locations.

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August 2006

RESEARCH PROJECT TITLE
Remote Continuous Evaluation of a Bridge Constructed Using High-Performance Steel

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Iowa Department of Transportation

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The Bridge Engineering Center (BEC) is part of the Center for Transportation Research and Education (CTRE) 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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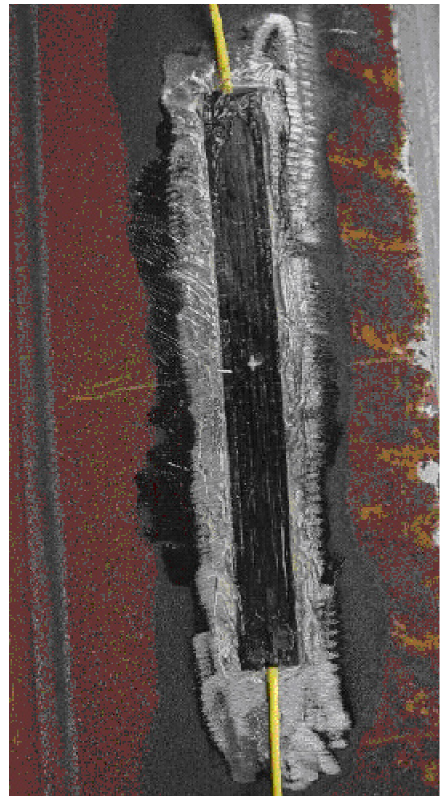
The bridge was tested with a controlled load truck and then opened to traffic on March 23, 2004, 10 months and 20 days after the original box girder bridge was closed for replacement. The bridge was subsequently monitored during ambient traffic loadings.

Key Findings

- The remote, continuous, fiber-optic based SHM system designed for and installed on the bridge generally met the objectives established for the project and acquired data successfully.
- The live data and video feed website has been useful for SHM, but continued problems with user interaction have occasionally disrupted data collection.
- The data collected have provided a baseline of bridge performance.
- Strain data from sensors used on the bridge were validated, and 22 of the 23 sensors proved to be accurate under live loading.
- Problems with long-term strain readings included interference between the sensors, a large strain range for the sensors, backscatter, etc.
- Monitoring the distribution factor from ambient traffic over time may prove useful should any significant changes occur.
- The strain plots of the ambient traffic and controlled load tests show very low levels of strain in the bridge's localized fatigue-sensitive details.

Implementation Benefits

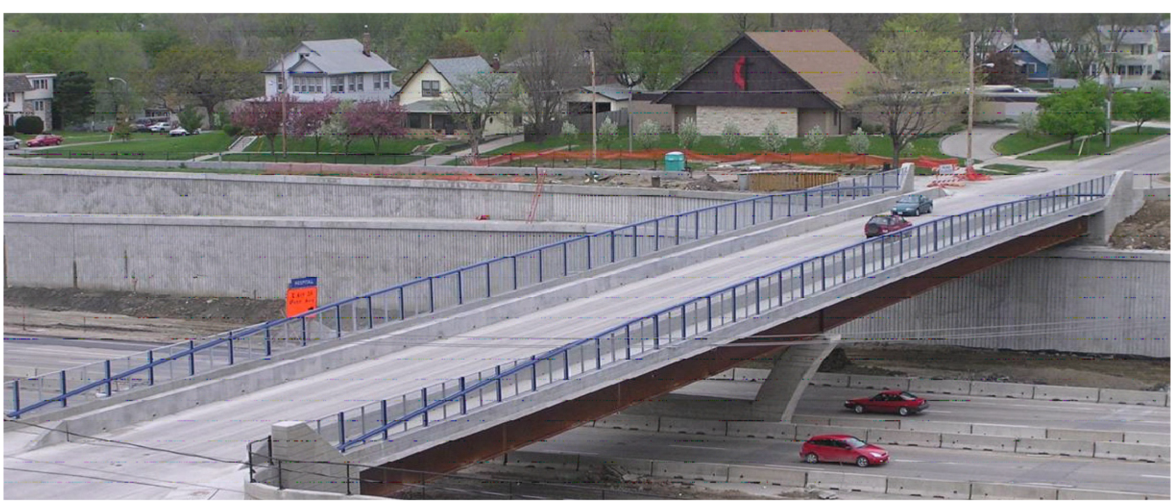
As a bridge replacement alternative, HPS can offer long-term benefits that may reduce maintenance costs and extend the useful life of bridges in Iowa. Additionally, a well-developed SHM system will have the potential to help transportation agencies better determine bridge maintenance and replacement schedules.



Installed surface-mountable sensor

Implementation Readiness

- Some problems were encountered with the strain sensors, and future work with continuous SHM should include using surface-mountable sensors, placing at least a 3 mm jacket on the cables, and testing different types of epoxy for attaching the sensors to the bridge.
- Continuous monitoring should be performed.
- To simplify data processing, a system should be developed that automates the processing and performs it in real time.



East 12th Street Bridge in Des Moines, Iowa