Michigan Department of Transportation
RESEARCH Administration

RESEARCH SPOTLIGHT

Project Information

REPORT NAME: Operational Baseline and Structural Health Monitoring for the 2nd Avenue Network Arch Bridge

START DATE: January 2022

REPORT DATE: December 2025

RESEARCH REPORT NUMBER: SPR-1762

PROJECT COST: $240,000

COST SHARING: 20% MDOT, 80% FHWA through the SPR, Part II, Program

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Long-term monitoring system for Detroit's 2nd Avenue Bridge

The 2nd Avenue Bridge over I-94 in Detroit is unlike any other bridge in the United States. Its innovative tied-arch design and accelerated construction methods allowed crews to build and install the bridge with minimal disruption to traffic below. Because of its unique design, the Michigan Department of Transportation (MDOT) launched a research project to better understand how the structure performs during construction and while in service. More than 100 sensors were installed throughout the bridge to monitor its behavior during its service life, and computer models were developed to better understand how the structure responds to traffic loads and seasonal temperature changes.

PROBLEM

Detroit's 2nd Avenue Bridge is one of the most complex bridges ever built by MDOT. Unlike a traditional steel or concrete bridge, the structure uses a tied-network arch design, where loads are transferred through a system of arches, cables and concrete components that work together to balance forces across the structure. The bridge crosses I-94 at an angle, adding another layer of engineering complexity.

Continuous monitoring of the 2nd Avenue Bridge is helping MDOT better understand how the structure performs over time and make more informed maintenance decisions.

Because of the unique design, engineers wanted to better understand how the structure would behave once exposed to real-world conditions such as heavy traffic, seasonal temperature swings and long-term aging. During the design phase, three separate computer models were created independently by the engineer of record, the contractor's consultant and a peer review engineer. Although all three models showed the bridge would perform safely, some differences existed due to varying assumptions within each model.

MDOT recognized the need to validate those assumptions after construction and establish a baseline understanding of how

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> *"This project is helping us build expertise in structural health and advanced bridge construction techniques. The data collected gives us a baseline understanding of how the structure behaves. With continuous monitoring, deviations from normal operation can inform proactive maintenance to ensure our bridges are safe for the travelling public."*
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> **Purushotham Pakala**
> Project Manager

the bridge behaves in service. Without real-world performance data, it would be difficult to determine whether future changes in the bridge's behavior reflected normal conditions or early signs of deterioration. MDOT also wanted to explore how continuous monitoring could support future bridge management decisions and reduce reliance on reactive maintenance practices.

RESEARCH

A comprehensive structural health monitoring system was installed on the bridge, including 112 sensors placed in key locations to measure strain and cable forces during construction and while the bridge was in service. Ninety-six of the sensors were embedded directly into the concrete during construction, while additional sensors were attached to the bridge hangers after the arches were erected.

Concrete samples were collected throughout construction to better understand how the bridge materials behaved over time under laboratory and real-world conditions. Researchers used this information to develop models estimating how the concrete would perform throughout its service life.

In addition to collecting field data, researchers developed advanced computer models of the entire bridge structure to predict how the bridge would respond under different traffic and environmental conditions. Researchers also conducted load testing by strategically positioning loaded trucks at multiple locations on the bridge and measuring how the structure responded.

RESULTS

The monitoring data confirmed that the bridge is performing as intended and operating safely within its design limits. Researchers found that stresses and strains throughout the structure remained within acceptable ranges during normal operation and controlled load testing.

The study also showed that the bridge is less affected by heavy traffic loads than expected, and seasonal temperature changes had a greater influence on how the structure responded over time. Based on these findings, researchers established expected operating ranges tied largely to temperature conditions.

One of the project's most significant outcomes was the development of a validated computer model of the bridge. Because the model was calibrated using real-world monitoring data, MDOT can now use it to study how the bridge may respond under future conditions that would be difficult or impossible to test in the field. For example, engineers can simulate how the structure might respond to changing traffic loads, potential damage or different repair strategies before work is performed on the bridge itself.

IMPLEMENTATION

This project provided MDOT with a long-term structural health monitoring system for the 2nd Avenue Bridge, allowing engineers to continuously track the structure's performance. The baseline data established through the research give the agency an important reference point for identifying changes in bridge behavior and planning preventive maintenance. This proactive approach can improve safety, reduce disruptions to traffic and support maintenance and repair decisions.

Beyond the immediate benefits for the 2nd Avenue Bridge, the project also gave MDOT valuable experience with structural health monitoring, computer modeling and innovative bridge construction techniques. The lessons learned support data-driven asset management in Michigan and may help inform future bridge projects involving complex designs and long-term monitoring.

Research Administration

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The final report is available online at
MDOTjboss.state.mi.us/TSSD/tssdResearchAdminDetails.htm?keyword=SPR-1762.

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