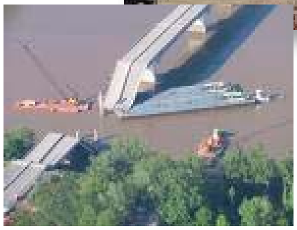
Prioritizing Infrastructure Repair

Objective

Provide the critical measurement science needed by FHWA and state Departments of Transportation (state DOTs) to better assess the status of aging infrastructure and enable cost-effective strategies for its maintenance, repair, rehabilitation, and replacement. This includes reducing uncertainty in bridge inspection, enabling more accurate modeling of structures (including weak links like welds, rivets, and bolts), quantifying the effects of extreme conditions, and qualifying new sensors for advanced inspection.

METALS

Impact and Customers



- The US depends on the multitrillion dollar transportation infrastructure investment to move goods and people to their destinations. The majority of this infrastructure is now over 50 years old and aging poorly. While we continue to repair and replace, we are not keeping up with the rate of deterioration. We need to develop more precise methods to detect the problems early and correct them before they increase in cost and danger to the public safety.
- NIST will provide a trusted scientific framework for consistent, objective assessment of infrastructural safety, while enabling improved bridge repair/installation, reducing cost to bridge owners and commuter downtime.
- NIST is working with FHWA and state DOTs on various bridge issues. We have presented our research plans at national bridge meetings to gather feedback from customers. In addition we have participated on bridge inspection visits to understand the practical problems in the field.

Approach

The Materials Reliability Division has partnered with the Metallurgy Division to address fundamental measurement problems associated with prioritizing the large backlog of infrastructure repair projects facing the U.S. Our combined approach includes development and application of new inspection methods and techniques. The resulting technology will enhance our ability to reliably inspect bridges and other infrastructure, and predict their performance under typical and extreme conditions. The activities within the Materials Reliability Division include:

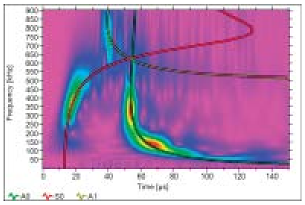
1. Establishing an acoustic emission calibration block facility to perform primary calibration of acoustic emission sensors, and to determine the effect of plate geometry on acoustic wave generation and propagation.
2. Developing a system for capturing waveform-based acoustic emission signals.
3. Developing a new resonant sensor concept, and evaluating its ability to determine strain magnitude in stressed plates.
4. Hosting a stakeholder meeting with private and federal customers to solidify research focus.
5. Upgrading the NIST large-load mechanical test system to enable comprehensive testing of aged and new infrastructure materials.

Accomplishments

Reduce error and uncertainty associated with existing bridge inspection instruments.

Many material defects or concealed elements may not be identified due to a nearly exclusive reliance on visual inspection. Nondestructive evaluation (NDE) tools have been developed to assist in bridge monitoring. However, their application in routine bridge inspections has been limited by the complexity and accessibility of these technologies, as well as a lack of guidance on how to use the methods in the field. Of particular concern is that certain methods can provide false readings (both positive and negative), due to improper calibration. An opportunity exists to expand the use of these advanced tools if one can reduce the error and uncertainty associated with their use, while also simplifying sensor output.

As part of the NDE tool development, acoustic emission will be evaluated for its potential in these applications. The absolute displacement measurement block described in ASTM Standard E1106 has been installed in one of the laboratories in the Materials Reliability Divisions. It will be used to calibrate the performance of other reference and industrial acoustic emission transducers in fundamental SI units, in discrete frequency intervals in the range 10kHz to 1MHz.



Wavelet Transform of AE Signal

Provide comprehensive testing and modeling of connections and components.

It is computationally impossible to model an entire structure down to the level of a rivet or bolt, but it is in these details that the critical failure conditions of the connections lay. Further refining the model by adding fatigue and corrosion of the materials at these critical links is also not currently possible. To address these deficiencies, measurement of how bridge connections degrade and the resulting effect on performance is necessary. These measurements and observations must then be converted into a simple but powerful numerical model to determine the current state of the overall system. Once established, this model will provide the necessary foundation for more accurately determining system safety during operation and will aid in establishing guidelines for sensor specifications and placement strategies for improved bridge inspection.

Quantify effects of extreme events on performance and remaining system strength.

Structural engineers design for expected service conditions using well-established, validated design rules backed by decades of experience. However, the performance of in-service structural elements under extreme conditions such as fire, explosion, impact, and natural disasters, especially for aged, degraded (corroded) conditions typical of the U.S. infrastructure, is poorly understood. Accurate estimation of the residual factor of safety for aged structures under normal and extreme conditions is critical to prioritizing the need for repair. NIST has unique capabilities for evaluating effects of high temperature (fire) and high strain rate (blast or impact) on material properties.

Anticipated long-haul freight traffic in 2035

Qualify new sensors for advanced inspection, including embedded approaches.

Some new bridges are implementing integrated sensing capabilities that monitor bridge environment (loads, temperatures, etc.). For example, the new St. Anthony Falls Bridge, which replaced the collapsed section of I-35W in Minneapolis, contains 240 sensors to measure traffic load, force on the concrete deck, temperature, and salt permeation. These sensors provide an unprecedented level of intelligence regarding bridge conditions. However, knowing the condition is just the start; structural health (i.e., the presence of flaws, cracks, debonding, and corrosion at critical connections) needs to be determined. To accomplish this goal, substantial technological advances are needed in sensor resolution, integration, and data interpretation.

Learn More

David McColskey
Marvin Hamstad
Stephanie Hooker
Ward Johnson
Jessica Terry
Chris McCowan

Tom Siewert
(Materials Reliability)
(303) 497-3523
thomas.siewert@nist.gov
www.nist.gov/msel/materials_reliability/

Publications

Hamstad MA, *Some observations on Rayleigh waves and acoustic emission in thick steel plates*, Journal of Acoustic Emission (in press 2010)

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