Toward a State of Good Repair for Railroad Bridges through Structural Health Monitoring

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An Asset Management Problem

Our transportation networks depend on a lot of physical infrastructure.

Consider the CTA North Mainline: track, earth retention, bridges, rolling stock…

How can we bring infrastructure in this network to a state of good repair with finite funding?
Let’s begin by asking a question:

How do infrastructure facilities (bridges) deteriorate?
In many cases, we have a pretty good idea *how* infrastructure facilities deteriorate:

What we don’t know is *how much* they have already deteriorated, *how quickly* the condition is worsening. That would help us prioritize repair, rehabilitation, and maintenance.
It would also be nice to know whether repair/rehabilitation efforts are effective.
So, how can we obtain the kinds of performance information we need to manage fixed transportation infrastructure assets?

- Inspections
- Examination of similar facilities
- Lab tests (at various scales)

The aim of this research is to add a new tool to the asset management toolbox: *structural health monitoring*, particularly of “fleet leader” or other exemplar facilities that represent a number of similar facilities.
What is Structural Health Monitoring (SHM)?

SHM is process of intelligently collecting data from sensors on critical components, transmitting data back to the office or lab, generating meaningful reports, making decisions, and taking action based upon live & historical data.
Built circa 1915 by Chicago, Milwaukee, and St. Paul RR

- Representative of many bridges on CTA North Mainline
- Identified by CTA as one of bridges with most advanced deterioration – fleet leader
CTA Devon-Sheridan Overpass

- Built circa 1915 by Chicago, Milwaukee, and St. Paul RR
- Two tracks of local Red Line service: 360 trains/weekday, 24 hours
- Two tracks Purple Line express service: 90 trains/weekday, rush hours only
Motivation for Structural Health Monitoring

General

• Supplement inspection programs with performance data between inspections
• Provide performance data for bridge components that are obscured or difficult to reach
• Measure quantities that are invisible to the eye – e.g., strain

CTA Devon-Sheridan Bridge

• Provide data for column and retrofit performance for management and prioritization of repairs for this and similar bridges

SHM is intended to supplement, not replace, visual inspection

SHM is best applied to aging, complex, non-redundant/fracture critical, or other special bridges
Three Challenges For Practical Structural Health Monitoring

1) How do we collect meaningful data?
   - Selection of quantities to measure; sensor and data acquisition choices

2) How do we get data off the bridge?
   - Robust methods for communication with the lab and archiving data in a central repository

3) What do we do with the data once we have it?
   - Automated data display and search capability for interpretation and decision-making
Challenge 1: Collecting Meaningful Performance Data

We want to know how quickly the concrete columns are deteriorating, but how can we measure it?
Collecting Meaningful Performance Data

We want to know how quickly the concrete columns are deteriorating, but how can we measure it?