FTA Field Experimentation Plan

Overview of Objectives and Instrumentation

Industry Partners Meeting - UIUC FTA Project Field Instrumentation

Outline

- Project Mission and Approach
- Industry Partners / Agencies and Current Timeline
- Critical Questions to Answer
- Test Site Overview
  - Instrumentation Overview
  - Instrumentation Maps
- Contact Information
Mission and Approach

• Mission:
  – Characterize the desired performance and resiliency requirements for concrete crossties and fastening systems, quantify their behavior under load, and develop resilient infrastructure component design solutions for concrete crossties and fastening systems for rail transit operators.

• Approach:
  – Quantify static loads (Paper Study)
  – Quantify dynamic loads (Field & Laboratory Study)
  – Develop finite element (FE) model of crosstie and fasteners (Numerical Modelling)
  – Use FE model, input loads, and laboratory verification to design more resilient crosstie (Design)
  – Deploy and monitor new crosstie design (Field Study)

FTA Project Approach

Field Experimentation

Laboratory Experimentation (RAIL at UIUC)

Analytical Finite Element (FE) Modeling

Linked together to maximize impact on design practices & standards
Partner Agencies

Field Instrumentation Timeline
MetroLink: Fall 2015
NYCT: Spring 2016 (Proposed)
Metra: TBD
TriMet: TBD

Static Axle Loads

We know what static loads are for transit vehicles and that they differ between modes. But what are the dynamic loads?
Critical Questions to Answer

- What are the in-service loads transit vehicles impart on the infrastructure?
- What are the maximum vertical loads experienced by the concrete crosstie at the rail seat?
- How much lateral restraint is necessary to prevent the rail from displacing or rotating outside of allowable tolerances?
- What magnitudes of flexural demands are transferred into crossties by transit vehicles?
- How much variability is there in the support conditions underneath the crosstie?

What questions do you, our industry partners, have that we should add?

Test Sites Overview

The instrumentation will be installed at a tangent and at a curve location
Instrumentation Overview

Vertical and Lateral Wheel Loads

- **Desired data:**
  - Vertical and lateral loads at the wheel-rail interface and rail seat

- **Instrumentation description and methodology:**
  - Industry standard strain gauge bridges applied to rail web and flange, similar to a wheel impact load detector (WILD) site
  - Based on previous UIUC field instrumentation, one instrumented crib per rail to approximate wheel loads throughout whole test section

Rail Seat Loads

- **Desired data:**
  - Rail seat load

- **Instrumentation description and methodology:**
  - This instrumentation is currently being tested and developed in the laboratory (crosstie- or rail-mounted strain gauges)
  - Three consecutive instrumented rail seats to capture distribution of forces as trains pass over test section
Instrumentation Overview

Rail Restraint

- **Desired data:**
  - Vertical and lateral rail base displacements

- **Instrumentation description and methodology:**
  - Linear potentiometers fixed to manufactured rapidly-deployable brackets that affix non-permanently to crosstie
  - Displacements measured at rail seats with instrumentation to:
    - Calculate rail rotation and translation

---

Crosstie Bending

- **Desired data:**
  - Crosstie center bending strains

- **Instrumentation description and methodology:**
  - Surface strain gauges mounted along the chamfer of the crosstie
  - Based on previous UIUC research, gauges will be placed at rail seats and center of crossties to account for most critical design moments
  - Intermediate gauges placed between rail seats and center will allow for more precise back-calculation of support conditions
Instrumentation Overview

Thermocouples

- **Desired data:**
  - Ambient and crosstie temperatures

- **Instrumentation description and methodology**
  - Surface thermocouples mounted on tie, below ballast, at rail seat, and near track
  - Based on previous UIUC research, thermal gradients warping the tie may cause support conditions to change

(May not be exact model/type used)

---

Pilot Instrumentation Map

Crosstie Bending Strain

- Vertical and Lateral Load (Wheel Loads)
- Rail Displacement (Base Vertical, Base Lateral)
- Rail Displacement (Base Vertical)
Final Instrumentation Map

*Final map may vary depending on results of pilot installation*

Acknowledgements

- **Funding for this research has been provided by:**
  - Federal Transit Administration (FTA)
  - National University Rail Center (NURail Center)
- **Industry partnership and support has been provided by:**
  - American Public Transportation Association (APTA)
  - New York City Transit (NYCT)
  - Metra (Chicago, Ill.)
  - MetroLink (St. Louis, Mo.)
  - TriMet (Portland, Ore.)
  - Pandrol USA
  - Rail Product Solutions (RPS), Inc.
  - LBFoster
  - GIC Inc.
  - Hanson Professional Services, Inc.
  - Amtrak

FTA Industry Partners:
Questions or Comments?

RAILTEC
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Riley Edwards
Senior Lecturer and Research Scientist
e-mail: jedward2@illinois.edu

Marcus Dersch
Senior Research Engineer
e-mail: mdersch2@illinois.edu

Yu Qian
Research Engineer
e-mail: yuqian1@illinois.edu

Matthew Csenge
Manager of Experimentation
e-mail: csenge2@illinois.edu

Aaron Cook
Graduate Research Assistant
e-mail: aacook2@illinois.edu

Xiao (Sean) Lin
Graduate Research Assistant
e-mail: xiaolin4@illinois.edu

General Research Topics
(for Discussion)

• Materials Level
  – Concrete mix design optimization due to climate
  – Need for air entrainment in concrete mix design
  – Fiber reinforced concrete (FRC)

• Component Level
  – Optimization of prestress
  – Corrosion of fastening systems
  – Concrete crosstie instrumentation with RFID (e.g. center strain gauges)
  – Rail pads for transit applications
  – Crosstie geometry trade off – length to surface area
General Research Topics
(for Discussion)

• **System Level**
  
  – Demands on the fastening systems for slab track vs. concrete crossties
  
  – Impact of crosstie spacing (looking into rail stresses)
  
  – System level testing to serve transit sector (model specification)
  
  – Under tie pads and ballast mats