UIUC Full-Scale Laboratory Track Bed

FRA Tie and Fastener BAA - Industry Partners Meeting
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Riley Edwards, Marcus Dersch, and Ryan Kernes

U.S. Department of Transportation
Federal Railroad Administration
RAILTEC
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Outline

• Current Experiments and Deficiencies
• Mission
• Objectives
• UIUC’s Full Scale Track System
  – Specifications
  – Phases
  – Schedule
  – Business Plan
    • Fixed Costs
    • Operating Costs
• Contact Information
Previous Laboratory Crosstie and Fastener Experimental Systems’ Deficiencies

- Unrealistic boundary and support conditions
- Unrealistic longitudinal rail restraint
- Examples of unrealistic loading
  - No or limited ability to vary lateral/vertical (L/V) load ratio
  - No ability to apply representative loading contact
  - No or limited ability to vary contact point
  - No ability to simultaneously apply load to both rail seats
  - No ability to simultaneously apply varying load magnitudes to adjacent rail seats
RailTEC Setup - Mission and Objectives

• Mission:
  – Design and execute a laboratory frame to accommodate representative full-scale track experimentation to improve the understanding of crosstie and fastening system component response and performance

• Objectives:
  – Improve upon existing full-scale crosstie and fastening system experimental setup deficiencies
  – Use wheel-rail contact to apply loads to track structure
  – Support track components with ballast, sub-ballast, and subgrade, compacted to achieve representative track stiffness
  – Facilitate multiple test protocols (e.g. static, dynamic) based on divergent experimental objectives
  – Ensure all varieties of track components can be accommodated
  – Facilitate measurement of loads, stresses, displacements, and strains
  – Allow for measurement of component degradation rates
# RailTEC Setup - Technical Capabilities

## Track Loading System Specification

<table>
<thead>
<tr>
<th>Specification</th>
<th>Purpose</th>
<th>Capability</th>
</tr>
</thead>
</table>
| 15' Frame Height    | Provide Realistic Support Conditions         | Construct varying full-depth track section designs  
*Initial track design: 34" of subgrade, 10" of sub-ballast, and 21.5" of ballast* |
| 30' Frame Length    | Provide Realistic Boundary Conditions        | Construct a multi-crosstie track panel to adequately distribute load and restrain rail in the longitudinal direction  
*Simultaneously study multiple track sections*  
*Initial track design: 11 crossties at 24" spacing* |
| 18' Frame Width     | Provide Realistic Boundary Conditions        | Construct a full-width track section without providing unrealistic lateral ballast confinement  
*Initial track design: 10.5' width at top of ballast and 1.75:1 design slope* |
## Technical Capabilities (Cont.)

<table>
<thead>
<tr>
<th>Track Loading System Specification</th>
<th>Purpose</th>
<th>Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Dimensions</td>
<td>Future Vision</td>
<td>Perform experiments on super-structure (varying crosstie and fastener design) and sub-structure (track transitions, ballast gradation, etc.)</td>
</tr>
<tr>
<td>Instrumented Wheel Set</td>
<td>Provide Realistic Loading Inputs</td>
<td>Ensure the applied load is imparted into the track system with realistic wheel/rail contact mechanics. Accurately quantify the load applied to the track structure</td>
</tr>
<tr>
<td>2 Actuators and 1 Ram</td>
<td>Provide Realistic Loading Inputs</td>
<td>Easily vary the lateral/vertical load ratio. Simultaneously apply various load magnitudes to each rail seat. Execute static, short term dynamic, and long term deterioration experiments. <em>Initial design: two-55 kip actuators and one-100 kip hydraulic ram</em></td>
</tr>
</tbody>
</table>
Full Scale Laboratory Track Bed: Design Plan and Wheel-Set Profile View

3" slots at $\phi 1\frac{1}{16}''$
Slots are 9" apart and run between upright columns.
Full Scale Laboratory Track Bed: Design Elevation View
Full Scale Laboratory Track Bed:
Full Scale Laboratory Track Bed:
Laboratory Track Bed Construction:
July 18 – Floor Beam Extension and Concrete Pad Complete
Laboratory Track Bed Construction: July 23 – Floor Constructed
Laboratory Track Bed Construction:
August 15 – Columns Erect and Walls and Floor Constructed
Laboratory Track Bed Construction: September 17–Lateral Structural Beams Installed
RailTEC Full Scale Track Experimental System

Laboratory Track Bed Construction: September 23 – Subgrade Construction ~50% Complete
Laboratory Track Bed Construction: October 4 – Subgrade Construction Complete
Construction Timeline and Path Forward

- **Construction**
  - Frame modification and connections \(\rightarrow\) April-July 2013
  - Frame assembly \(\rightarrow\) July-October 2013
  - Track construction \(\rightarrow\) September-October 2013
    - Rail, ballast, subballast, and subgrade supplied by CN
    - Crossties supplied by LBFoster CXT Concrete Ties
    - Fastening systems supplied by Amsted RPS
    - IWS calibrated and provided by TTX

- **Hydraulic Systems Installation**
  - Hydraulic system and actuators purchased from MTS
  - Hydraulic cooling system purchased from BAC

- **Path Forward**
  - Development of experimental matrix and instrumentation plan \(\rightarrow\) September-November
  - Shakedown \(\rightarrow\) November-December 2013
  - Execution of experimental matrix \(\rightarrow\) December 2013-April 2014
Experimental Matrix Objectives

• Compare to field and laboratory experimentation
  – TLV
  – Train passes
  – PLTM

• Expand upon current field and laboratory experimentation capabilities

• Fill voids in field and laboratory experimentation

• More accurately validate the UIUC 3D FE Model

• Analyze innovative crosstie and fastening system designs
Experimental Matrix Variables

- **Load Location**
  - Crib center, tie center, tie edge, skewed load (e.g. rail 1 = tie center while rail 2 = offset from tie center)

- **Load Magnitude**
  - Balanced, unbalanced (e.g. rail 1 = 50 kips while rail 2 = 30 kips)

- **Fastening System Clips**
  - 100% installed, 1 rail seat removed, multiple rail seats removed, vary type, vary clamping force (full, reduced, none)

- **Rail Pad and insulator materials**
  - Typical, stiff, flexible

- **Friction**
  - Dry, wet, various friction modifiers

- **Other**
  - Gaps at fastening system interfaces, ballast support condition, deterioration tests
Future Phases

- To be developed when future projects deem necessary and under separate funding

- Load application:
  - Two instrumented wheel sets
  - 6 hydraulic actuators
  - Rolling load

<table>
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<tr>
<th>Part</th>
<th>Capability</th>
<th>Phase</th>
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</thead>
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<tr>
<td>2nd Instrumented Wheel Set</td>
<td>Ability to investigate wheel spacing and affect of adjacent loading as well as simulate steering of trucks</td>
<td>Future</td>
</tr>
<tr>
<td>6 Actuators</td>
<td>Ability to provide additional control and variability of loading to the track structure</td>
<td>Future</td>
</tr>
<tr>
<td>Drive system</td>
<td>Ability to apply dynamic rolling load</td>
<td>Future</td>
</tr>
<tr>
<td>Extension of Frame</td>
<td>Ability to achieve higher speeds, study additional sections simultaneously, and study track transitions</td>
<td>Future</td>
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Future Phase – Full Truck Loading

- Additional wheel set (full truck)
- Independent control of both wheel sets
  - Simulate steering of trucks
- One lateral and one vertical actuator per wheel set
- One hydraulic ram on opposite end of axle on each wheel set
- Addition of second vertical actuator on each wheel set to provide additional control and variability of loading on second side of axle
Future Phase – Full Truck Loading
Future Phase – Full Truck Loading
Future Phase – Moving Truck (Loads)

• Addition of drive system to move truck longitudinally
• Apply continuous rolling loading to track
• Extend frame length
Future Phase – Moving Truck ( Loads)
Future Phase – Moving Truck (Loads)
Industry Support

- **UIUC, CEE Department, and RailTEC**
  - Provision of Laboratory Facility
  - Cleanup and Retrofit of Laboratory
  - Hydraulic Power Supply and Ancillary Equipment

- **Other Industry Partners**
  - Instrumented Wheel Set (IWS) [TTX]
  - Frame Price Reduction [Amsted Rail]
  - Hydraulic Power Unit Chiller [Amsted Rail]
  - Track Construction Materials [CN Railroad]
  - Track Construction Quality Control [Hanson Professional Services Inc.]

- **Federal Railroad Administration (FRA)**
  - Additional Frame Design, Materials, and Labor
  - Actuators
  - Control System
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  - Hanson Professional Services, Inc.
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  - TTX Company

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Contact Information

J. Riley Edwards
Senior Lecturer
jedward2@illinois.edu

Marcus S. Dersch
Research Engineer
mdersch2@illinois.edu

Ryan G. Kernes
Research Engineer
rkernes2@illinois.edu

Rail Transportation and Engineering Center - RailTEC
Department of Civil and Environmental Engineering
University of Illinois at Urbana-Champaign
205 North Mathews Avenue
Urbana, Illinois 61801