Tie and Fastener Research at TTCI

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Tie and Fastener Research at TTCI – Outline

♦ TTCI Site Overview
♦ Tie Fastener Research Overview
♦ A Flavor of AAR Funded Tie/Fastener Research Tasks
  ● Ballast-tie interface pressure measurement
  ● Under-tie ballast imaging
  ● Lateral Track Loading Fixture (LTLF) testing
  ● Other ongoing data collection and tasks
♦ Developing a tie/fastener degradation costing model
♦ Summary
Tie and Fastener Research at TTCI

♦ FRA funded research
♦ Commercial/proprietary research
♦ AAR funded research:

● Objective:
  ▲ Improve the performance of track through improvements of the tie/fastener system
● End Product(s):
  ▲ Improved performance tie/fasteners, better recommendations for implementing improved performance systems, better understanding of where and why failures occur
Ballast-Tie Interface Pressure Measurement

- Characterizing the load environment on the underside of the tie
- Ballast-tie “peak pressures” measured under HAL
- Laboratory and in-track testing
- Sensor measures fine-scale distribution
- A means to quantify ballast degradation and effect on load environment
- Two reports published for 2014
**Ballast-Tie Interface Pressure Measurement**

<table>
<thead>
<tr>
<th>Ballast Material</th>
<th>Average Peak Pressure @ 20 kip applied</th>
<th>Percent of Uniform Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>283.9 psi</td>
<td>399%</td>
</tr>
<tr>
<td>Pea Gravel</td>
<td>444.1 psi</td>
<td>624%</td>
</tr>
<tr>
<td>H. Degraded Ballast</td>
<td>681.3 psi</td>
<td>958%</td>
</tr>
<tr>
<td>Mod. Degraded Ballast</td>
<td>929.7 psi</td>
<td>1307%</td>
</tr>
<tr>
<td>New Ballast</td>
<td>1449.9 psi</td>
<td>2036%</td>
</tr>
</tbody>
</table>

(a) New Ballast  
(b) Mod. Degraded Ballast  
(c) Heavily Degraded Ballast  
(d) Pea Gravel  
(e) Sand
Ballast-Tie Interface Pressure Measurement

- Peak areas of pressure were adjacent to the rail (tamped area) in 60% of tests
- Distribution varies significantly from that proposed in AREMA
Section 3 Concrete Tie Test Zones:

- **Zone 1 (190 Half-Frame Ties 24” Spacing)**
  - 4 Clips per Tie

- **Zone 2 (100 Conventional Ties Control Zone 24” Spacing)**
  - 6 Clips per Tie

- **Zone 3**
  - 100 CXT 200GBP Ties Factory Installed Under Tie Pads 24” Spacing

- **Zone 4**
  - 100 Used Conventional Ties Field Installed Under Tie Pads 24” Spacing

- **Zone 5 (63 Used Conventional Ties 20” Spacing)**

*Reconfigured after 140 MGT from 8 clips/tie to 6 clips per tie due to end tab cracking*
Section 3 Ballast Degradation Imaging Analysis

- To determine the reduction in ballast degradation, if any, observed beneath under tie pads and half-frame ties
- Full cross-sectional trenches were dug and ballast images collected – data currently being analyzed
- Working with University of Illinois to quantify particle size to compare the five test zones
- If ballast is lasting longer, ties are performing one of their key functions better = cost savings
Section 25 – Lateral Track Loading Fixture (LTLF) Tests

- Test to indicate gage restraint of tie/fastener systems

- Wood ties w/ AREMA 14” plates - control
- 2 Composite tie zones – 1400+ MGT
- Concrete tie zones – 800 MGT
- Wood tie w/ elastic fasteners – 800 MGT

- Applying load as traditionally done on the web as well as at the head of the rail – increased resolution?
Section 25 – Lateral Track Loading Fixture (LTLF) Tests

Average Gage Widening at Head for Four Tie/Fastener Systems at 650 MGT

- **Rocola Concrete**
  - Pandrol Safelok I
  - Zone 4

- **Mixed Hardwood**
  - Pandrol Victor, e-clip, drive spike hold down Zone 0B

- **Mixed Hardwood**
  - AREMA 18", cut spikes
  - Zone 13

- **Mixed Hardwood**
  - AREMA 14", cut spikes
  - Zone 1
Section 25 – Lateral Track Loading Fixture (LTLF) Tests

Average Gage Widening for Four Wood Tie/Fastener Systems at 650 MGT

- Gage widening at head
- Gage widening at base

<table>
<thead>
<tr>
<th>System</th>
<th>Gage Widening at Head</th>
<th>Gage Widening at Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed Hardwood</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Pandrol Victor, e-clip, cut</td>
<td>0.05</td>
<td>0.15</td>
</tr>
<tr>
<td>spike hold down Zone 0A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixed Hardwood</td>
<td>0.15</td>
<td>0.25</td>
</tr>
<tr>
<td>Pandrol Victor, e-clip, drive</td>
<td>0.05</td>
<td>0.15</td>
</tr>
<tr>
<td>spike hold down Zone 0B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixed Hardwood</td>
<td>0.25</td>
<td>0.35</td>
</tr>
<tr>
<td>AREMA 18”, cut spikes Zone 13</td>
<td>0.15</td>
<td>0.25</td>
</tr>
<tr>
<td>Mixed Hardwood</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td>AREMA 14”, cut spikes Zone 1</td>
<td>0.15</td>
<td></td>
</tr>
</tbody>
</table>

WEB APPLIED LOAD = 9 KIPS
Section 25 – Lateral Track Loading Fixture (LTLF) Tests

Key findings/results:
- Applying load at head does not appear to increase resolution in data for elastic fastening systems – too small of displacements.
- Applying load at head increased gage widening resolution for AREMA plates/cut spikes however.
- No difference seen in gage restraint for cut spike hold downs vs. drive spike hold downs on Pandrol Victor plates after 650 MGT.
- Elastic fasteners on wood ties:
  - Roughly 2x higher gage restraint than 18” AREMA plates
  - Roughly 3x higher gage restraint than 14” AREMA plates
  - Similar gage restraint performance to concrete ties
Other ongoing data analysis

- Crib ties:
  - Panel shift test
  - Track stiffness
  - Gage restraint (GRMS and LTLF)
- Cont. analysis of maintenance records
  - Tie plate breakage
  - Screw/drive spike breakage
- Geometry data
  - Correlating track geometry data with tie/fastener test zones at FAST
  - Geometry history for revenue service install of Half-Frame ties
Tie/Fastener Degradation and Costing Analysis

- Focus of the project thus far has been testing specific tie/fastener systems and quantifying their relative performance.
- The next step is to understand why – i.e. the driving factors.
- Proposed: an analysis to quantify “real world” performance.
  - Creating a database of Class I tie lifecycle data.
  - Correlating this data to mechanistic load environment.
    - e.g. plate size/stress to plate cutting potential.
    - Location of hold down spike to tendency for spike failure.
    - Enhancements to Railway Track Lifecycle Model (RTLM).
- Ultimate goals:
  - More informed forecasting/planning/purchasing.
  - Better recommendations for design.
  - Better assessment of cost vs. benefit.
Developing Tie Degradation/Costing Analysis

- Characterizing load environment
- Laboratory testing
- Field verification
- Mechanistic behavior

**GOAL:** understanding of the factors that drive tie/fastener performance

- Database of tie
  - Location
  - Tonnage
  - Age
  - Geometry
  - Curvature
  - Climate
Summary:

- Ballast-tie interface data – a step towards quantifying the true pressure distribution on the underside of the tie
  - High ballast pressures lead to increased deterioration
  - Can the tie be improved to reduce this effect?
- Ballast x-section imaging will quantify degradation
  - Savings due to larger footprint ties and under-tie pad treatments?
- Gage restraint measurement using LTLF
  - Little significant degradation thus far
  - Gage restraint appears to be more inherent to the fastening system until a failure occurs.
- Developing a degradation and costing approach
  - Mechanistic analysis and laboratory testing to characterize load environment
  - Correlating failure mechanisms with load environment and climate
  - Lifecycle and failure data from railroads/subdivisions will be vital
  - A better approach to cost vs. benefit
Thank you for your time

Questions?

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