IMPROVEMENT OF CROSSTIE-BALLAST CONTACT USING UNDER TIE PADS IN HEAVY HAUL LINES

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Topics to be covered

- MRS Logistics and Vale S.A. study
- Introduction and the research purpose
- Techniques to Reduce Ballast-Tie Pressures
- Experimental Work
- Results
- Conclusions
MRS Logistics and Vale S.A

- Both companies are renewing their track lines to increase their transport loads;
- Replacing wood Ties to concrete Ties.

**Vale - Estrada de Ferro Carajás” (EFC)**
Main transport: iron ore;
Length: 892 km (double);
Typical train: 3 locomotives and 332 wagons - 260 MGT/year;
Track superstructure: 136RE rails, concrete Ties, fastclip fasteners system.

**MRS Logistics**
Main transport: iron ore >70%;
Length: 1.700 km;
Typical train: 3 locomotives and 134 wagons – 190 MGT/year;
Track superstructure: 136RE rails, wood, concrete and steel Ties, elastic fastener system.
Main project

Track mechanical behavior evaluation. Substructure and superstructure components.
• Alternative types of ties, fasteners systems and Pads.

This paper:
• Evaluates the Tie-ballast contact; The effects of using Under Tie Pad;
Main project

Track mechanical behavior evaluation. …many sensors, lot of technologies, but a simple objective: improve the track quality and reduce the maintenance costs.
Challenges of replacing wood by concrete

- The structure must be resilient in order to dissipate the rolling stock energy while maintaining the geometry;
- Each component of the structure must perform its desired functions;
- The introduction of concrete ties the track structure became significantly stiffer;
- Is necessary to reevaluate the track structure and its components.

.... improve to take full advantage of concrete tie potential
Tie-Ballast contact

The number of aggregates involved in directly Tie supporting is relatively small and depends on:
- Ballast grading;
- Ballast shape;
- Tie dimension;
- Load.

Ref: Getzner

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Jeffs e Tew, 1991

Shenton, 1975
Bearing Stress on Tie Bottom

Bearing stress varies by repeatedly passing wheel loads and the accumulation of the tonnage transported (DOYLE, 1980).

This behavior may become significantly high after a few million load cycles and change the aggregates shapes.

The ballast undergoes irrecoverable plastic deformation and particle degradation, in addition to recoverable elastic strains.

The ballast stress strain behavior directly affects in maintenance cycles.
# Techniques to Reduce Ballast-Tie Pressures

<table>
<thead>
<tr>
<th>Technique</th>
<th>Description</th>
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<tr>
<td><strong>Under Tie Pads</strong></td>
<td>The application of this technology to heavy haul lines is not common.</td>
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<tr>
<td><strong>Frame or half-frame ties</strong></td>
<td>Increases the weight of the Tie and the maintenance costs</td>
</tr>
<tr>
<td><strong>Use of smaller ballast grading</strong></td>
<td>Reduces the ballast drainage and resistance</td>
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Ref: Getzner

Lichtberger, 2011
Experimental Work

MRS Logistics:
- Concrete Ties with UTP were installed in December 2014.
- Tangent track Test Site.
- Ballast: AREMA 24
- Tones/axle: 36 – 39
- MGT accumulated: 200

Vale S.A:
- Concrete Ties with UTP were installed in January 2015.
- 24 in spaced
- Curve track Test Site.
- Ballast: AREMA 24
- Tones/axle: 36
- MGT accumulated: 250
Pressure measurement – MBTSS (Matrix Based Tactile Surface Sensor)

We used very thin rubber membrane with Teflon layer (1/8 in) to avoid any resolution problem and measurements errors.

The thicker rubber protection has the effect of distributing the discrete loads across more area of the sensor.

Although it affected the sensor durability.
Results - Bearing Stress under rail

Without UTP

unload

load cycle

With UTP

unload

load cycle

23 inches
Results - Contact area – New ballast

- Reduces the ballast breakdown
- Reduces the ballast settlement

Entire Tie contact area %

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<th></th>
<th>Without</th>
<th>With UTP</th>
<th>Wood</th>
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<tbody>
<tr>
<td></td>
<td>22 to 32</td>
<td>57 to 64</td>
<td>46 to 55</td>
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≈ 3 times more contact

(DB – after 190 MGT) – Getzner 2012

Expected:
- Reduces the ballast breakdown
- Reduces the ballast settlement
Results - Contact area x time

1 locomotive + 134 wagons + 1 locomotive
30 mph

Contact area %

Time, Seconds

63% with USP
22% without USP
Results - Longitudinal rail level

Longitudinal rail level VALE Carajás Line UTP test section

less tamping cycle in this area
Results - Longitudinal rail level

Longitudinal Rail Level in VALE Carajás Line UTP test section KM 391

UTP Section

Alignment Jan 2015

Avg. of Test Period with all insecurities to show the basic trend
Results - Bearing Stress under rail

46 to 53 % of the axle load was measured on the tie

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<th>Average pressure distributions (PSI)</th>
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<tr>
<td>Without</td>
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<tr>
<td>150 to 230</td>
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Measurements of the pressure distribution along the length of the tie showed *variability between test ties*.

Peak pressures up to 15 times times higher than the uniform pressure!
Next steps…

- Evaluate the ballast degradation - sieving tests. Tests will be performed after 700 MGT (July 2018).

- Evaluate different types of pads due variability of solutions and purposes.
Conclusions/discussions

• The geosynthetic pad increases the contact between the ballast and preserves both components under dynamic load;

• UTP shows improvements of resilience in the track system - allows greater amplitude of the contact area of the ballast, involving more aggregates during the dynamic loading, thus lowering the impact force on the ballast bed caused by “hanging” Ties;

• The peak and average vertical cyclic stress decreases significantly with the introduction of under Tie pad;

• The test track highlights that the use UTP extend the intervals between tamping and ballast settlement.

• Has been found that the higher the traffic loads and the more frequently a track section is used, particularly for tight curves, the more cost-effective UTPs are;

• In conclusion, it can be stated that the introduction of UTPs on heavy haul lines as demonstrated significant life cycle cost savings.

• More research to evaluate the peak pressure to reduce the potential of ballast or tie degradation.
....improve the track quality and reduce the maintenance costs.

.... improve to take full advantage of concrete tie potential.

.... think not only on initial costs, but in long term evaluation.

Thank you!

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