Concrete Tie History in North America
and
A New Look at Wood Ties for Latin American Railroad Applications

Prepared for:
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We’ll Look At

• Experience w/ Concrete Ties in North America

• Environmental Life Cycle Analysis of Wood Ties vs. Alternative Ties

• Review of New Wood Preserving Technologies for High Decay Areas
First a Couple of Points About Wood

- Wood is used for 94% of track applications in the US and Canada – 23+ million annually
- Numerous properties that are hard to match
  - Resilient, strong, 150 yr. history of excellent performance
Introduction

- RTA project to determine life of concrete ties based on experience of North American freight railroads and other rail systems.

- Data was collected from all of the major US and Canadian Railways with concrete tie experience.
  - Also from smaller US rail systems with concrete tie experience.
  - Focus on available railroad and industry data on concrete crosstie performance under railway operations in the US & Canada.

- Resulting data was analyzed to provide an assessment of actual concrete tie life, as experienced in North American railway environment.

- Objective to obtain estimates of concrete tie life.
  - Based on actual failure rates by failure category.
Modes of Concrete Tie Failure

- Concrete tie performance (and life) was divided into three categories:
  1. Premature manufacturing or chemical interaction related failures
     - Alkali-Silica Reactivity (ASR), Alkali-Aggregate Reactivity (AAR), Delayed Ettringite Formation (DEF), inadequate Air-Entrainment, etc.
  2. Mechanical (vehicle-track dynamic) or service related failures
     - Cracking under dynamic impact loads (rail seat cracking), cracking due to tie resonance, rail seat abrasion, etc.
  3. General railroad service which includes:
     - Heavy axle load freight railroad
     - Passenger railroads and transit

- Overall concrete tie life was obtained by mathematically weighting failure rates in each of three categories.
Railseat Abrasion
Note: Not to Scale
Data Sources

• Questionnaire sent to each of the major Class 1 Freight railway users of concrete ties.
  – BNSF
  – CSX
  – CN
  – NS
  – UP

• Additional tie concrete failure information obtained from other sources, to include studies on transit and other rail systems that experienced concrete tie failures.
  – Amtrak
  – Black Mesa and Lake Powell RR
  – Metro North Rail Road
  – New Jersey Transit
  – MBTA, Boston MA
  – MTA Light Rail, Baltimore, MD
  – Tren Urbano, San Juan, Puerto Rico
APPENDIX A
SURVEY OF NORTH AMERICAN CONCRETE TIE PERFORMANCE

- Railroad ________________________________
- Total number of Track Miles ______________________________
- Total number of track miles with concrete ties __________________
- Installation History of Concrete Ties
  - 1970- 1980 Number of concrete ties installed ______________
  - 1980- 1990 Number of concrete ties installed ______________
  - 1990- 1995 Number of concrete ties installed ______________
  - 1995- 2000 Number of concrete ties installed ______________
  - 2000- 2005 Number of concrete ties installed ______________
  - 2005-2010 Number of concrete ties installed ______________

Performance/Failure History:
- Premature manufacturing or chemical interaction related failures, which includes AAR, ASR, DEF, etc,
  - 1970- 1980 No. of failed ties _________  Failure mode ______  Yr installed _______
  - 1980- 1990 No. of failed ties _________  Failure mode ______  Yr installed _______
  - 1990- 1995 No. of failed ties _________  Failure mode ______  Yr installed _______
  - 1995- 2000 No. of failed ties _________  Failure mode ______  Yr installed _______
  - 2000- 2005 No. of failed ties _________  Failure mode ______  Yr installed _______
  - 2005-2010 No. of failed ties _________  Failure mode ______  Yr installed _______

- Mechanical related failures such as rail seat abrasion, rail seat cracking, bottom abrasion, insert failure, and damage by derailment or other impact (tamper, regulator strikes etc.)
  - 1970- 1980 No. of failed ties _________  Failure mode ______  Yr installed _______
  - 1980- 1990 No. of failed ties _________  Failure mode ______  Yr installed _______
  - 1990- 1995 No. of failed ties _________  Failure mode ______  Yr installed _______
  - 1995- 2000 No. of failed ties _________  Failure mode ______  Yr installed _______
  - 2000- 2005 No. of failed ties _________  Failure mode ______  Yr installed _______
  - 2005-2010 No. of failed ties _________  Failure mode ______  Yr installed _______

- General Performance History of Concrete Ties
  - Percentage of concrete ties installed in 1970- 1980 removed from service __________
  - Percentage of concrete ties installed in 1980- 1990 removed from service __________  Percentage of concrete ties installed in 1990- 1995 removed from service __________
  - Percentage of concrete ties installed in 1995- 2000 removed from service __________  Percentage of concrete ties installed in 2000- 2005 removed from service __________
  - Percentage of concrete ties installed in 2005-2010 removed from service __________
  - Average life of concrete ties currently in service __________
Reported Concrete Tie History: CN

• Canadian National was earliest user of concrete ties among the major US and Canadian railroads.
  - Initial installations occurring in 1972

• Approximately 700,000 concrete ties installed in 1970s and another 2,800,000 ties in 1980s.
  – Subsequent installations were primarily replacement at approximately 25,000 to 45,000 ties per year.
  – Total installation of 3,900,000 ties

• Analysis of installation and failure data showed average age of concrete ties in track of 22.4 years.
CN Rail (Cont’d)

• Initial installations included a significant number of ties that had premature failure due to chemical or manufacturing related deficiencies.
  – Alkali Reactivity.
  – Of initial 700,000 ties installed, approximately 53% experienced failure and were replaced.

• Subsequent tie failures included rail seat abrasion, rail seat cracking and limited replacement because of damage from derailments or dragging equipment.

• Of the 3,900,000 concrete ties installed, approximately 1,100,000 failed and were replaced.
  – Failure rate of 27.1%.

• Calculated forecast life of concrete ties based on CN experience is 41.3 years.
  – Based on median life corresponding to 50% of ties having failed.
CN Concrete Tie Failure Rate

<table>
<thead>
<tr>
<th>Tie Installation Period</th>
<th>% Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-1980</td>
<td>60.0%</td>
</tr>
<tr>
<td>1981-1990</td>
<td>10.0%</td>
</tr>
<tr>
<td>1991-1995</td>
<td>10.0%</td>
</tr>
<tr>
<td>1996-2000</td>
<td>10.0%</td>
</tr>
<tr>
<td>2001-2005</td>
<td>10.0%</td>
</tr>
<tr>
<td>2006-2010</td>
<td>10.0%</td>
</tr>
</tbody>
</table>
BN/BNSF

- Burlington Northern and Burlington Northern Santa Fe (BNSF) started installing concrete ties in 1970s.
- BNSF has installed more than 10 Million concrete ties.
  - Average age of concrete ties in track is less than 15 years.
- Performance of concrete ties has been good, with only minimal failures.
- Issues such as rail seat abrasion are repaired in situ without removing or replacing.
NS

• NS has smallest number of concrete ties of major US railroads.
• Total of approximately 38,000 concrete ties installed
  – Includes small test batches installed in 1970s and 1980s
  – Larger test batches installed in 1990s.
• Follows behavior and degradation of concrete ties very closely.
  – Very good statistics on failure rate of each installation batch.
• Of 38,036 concrete ties installed by NS, 27,310 ties were removed
  – Failure rate of 71.8%
  – For failure in concrete quality, rail seat abrasion or rail seat cracking.
• Weighted forecast life of concrete ties on NS of 19.5 yrs
• NS internal analyses indicated that investment on concrete is not justified
NS Concrete Tie Installation and Failure Rate

NS Concrete Ties Installed vs Ties Failed

Period

Number of ties

0
5000
10000
15000
20000
25000

1970-1980
1981-1990
1991-1995
1996-2000
2001-2005
2006-2010

Concrete ties installed
Concrete ties failed

NS Concrete Tie Failure Rate

% Failure

0.0%
20.0%
40.0%
60.0%
80.0%
100.0%

1970-1980
1981-1990
1991-1995
1996-2000
2001-2005
2006-2010

Tie Installation Period
CSX

- CSX has been an active user of concrete ties since the 1980s.
- Over 2 Million concrete ties installed.
- Ties installed in the 1980s had a 10.6% failure rate, primarily due to Alkali-Aggregate Reactivity (AAR) failure.
- Failure rate for subsequent tie installations was lower, primarily due to rail seat abrasion and rail seat cracking problems associated with the removal of ties.
- Overall concrete tie failure rate on CSX was 5.7%.
CSX Concrete Tie Installation and Failure Rate

**CSX Concrete Ties Installed vs Ties Failed**

- **Number of ties**
  - 1970-1980: 1000000
  - 1981-1990: 600000
  - 1996-2000: 400000
  - 2001-2005: 200000
  - 2006-2010: 0

**Period**
- 1970-1980
- 1981-1990
- 1991-1995
- 1996-2000
- 2001-2005
- 2006-2010

**CSX Concrete Tie Failure Rate**

- **% Failure**
  - 1970-1980: 12.0%
  - 1981-1990: 10.0%
  - 1991-1995: 6.0%
  - 1996-2000: 2.0%
  - 2001-2005: 0.0%
  - 2006-2010: 0.0%
The Union Pacific is a major user of concrete ties with almost 8 Million concrete ties installed since 1982.

No failure data is available.
- Failed ties usually removed by local forces and not centrally reported.

Recent due to manufacturing quality control upwards of 500,000+ failures.
- Replacements ongoing

Maintenance problems are primarily rail seat abrasion related, repaired in situ without having to remove or replace ties.
- Done normally as part of a regularly scheduled rail renewal operation or by using a special rail seat abrasion repair gang.

More than 60% of total concrete ties installed within last 10 years, with failures reported in recent years.
AMTRAK

• Amtrak is major user of concrete ties with approximately 3.4 Million ties in service.
  – Highest percentage of track with concrete ties- approximately 65+ %

• Has been installing concrete ties since late 1970s.

• Has experienced two major sets of concrete tie failure.
  – Approximately 355,000 ties installed in 1980s that failed due to Alkali-Aggregate Reactivity (AAR).
  – Current set of manufacturing related failure (ASR) that affects approximately 800,000 ties,
    • Majority have not yet been replaced.
    • Expectation is that a significant percentage (if not all) of these ties will be replaced.

• Correspond to a 22 to 34% concrete tie failure rate.
Other Passenger and Freight Railroads

• Additional data obtained from selected railways and transits.
  – Available data as related to concrete tie performance and failure.

• Black Mesa and Lake Powell RR
  – Utility RR carrying coal to power plants in Southwest US.
  – Approximately 175,000 concrete ties installed in the 1973.
  – 100% replaced in 2002 for Alkali-Silica Reactivity (ASR).
  – Concrete tie life of 29 years.

• Metro North Rail Road
  – Commuter railroad in the New York City Metropolitan area.
  – Approximately 50,000 concrete ties installed in mid-1990s.
    • 100% removed due to Delayed Ettringite Formation (DEF)
  – 260,000 concrete ties installed in late 1990s.
    • Scheduled to be replaced for ASR.
Other Passenger and Freight Railroads (Cont’d)

- **New Jersey Transit**
  - Commuter Railroad in New York City Metropolitan area
  - Approximately 27,000 concrete ties were installed in mid-1990s.
  - 100% removed due to Delayed Ettringite Formation (DEF).

- **MBTA, Boston MA**
  - Commuter railroad in Boston Metropolitan area
  - Approximately 150,000 concrete ties installed in mid-1990s (1997)
  - 100% scheduled for removal in 2010 due to DEF – Settlement reached
  - Concrete tie life of 13 years.

- **MTA Light Rail, Baltimore, MD**
  - Light Rail transit system of Baltimore Boston.
  - Approximately 202,000 concrete ties installed in the early 2000s.
  - 200 ties (0.1%) have failed and been replaced to date.

- **Tren Urbano, San Juan, Puerto Rico**
  - Transit system of San Juan, Puerto Rico.
  - Approximately 22,000 concrete ties installed in mid-1990s.
  - 2000 ties (9.1%) have been replaced due to ASR.
  - Expectation is majority of ties will be replaced over next several years.
Cracks in concrete ties Mexico, Jan. 2012
Midline crack in concrete tie
Mexico, Jan. 2012
Moderate to severe cracking and breaking Mexico, Jan. 2012
Tie Failures
Mexico, Jan. 2012
Summary

• Study examined approximately 29 Million ties installed on US/Canadian rail systems since 1970s.
• Approximately 2.2 to 2.7 Million ties were reported as failed and replaced or scheduled to be replaced
  – Corresponds to a failure rate of 7.9 to 9.2 %
  – Average age of concrete ties is of order of 13 years
• Analysis performed on population of concrete ties in track for 20 or more years
  – Installed in the 1970s and 1980s
  – Population of 7.4 Million ties
  – Approximately 1.6 Million have been reported as failed and replaced
    • Failure rate of 22.2 %.
  – Depending on assumed time in service, failure rate projects to a service life of just over 40 years
Summary (Cont’d)

• Railroad with longest average time in track, for concrete ties, is CN
  – 22.4 year weighted average age
  – CN has a projected tie service life of 41.3 years

• A reasonable estimate for concrete tie service life under North American railroad operating conditions is between 40 and 42 years.

• Concrete ties with rail seat abrasion that are not removed from track (per BNSF and UP practice) will periodically require expensive in-situ repair.
Life Cycle Assessment Project Update, Preliminary Findings, and Related Issues
October 7, 2011

Prepared for

AquaeTer

Railway Tie Association

ENERGY | ENGINEERING | ENVIRONMENTAL | RISK | SUSTAINABILITY
Creosote-Treated RR Ties LCA
Life Cycle Inventory

- **Inventory-Creosote-Treated Ties**
  - Inputs - Wood, Creosote, Energy
  - Outputs
    - Products - Treated ties
    - Releases - CO2, NOx, PAH, etc.

- **Inventory Alternate Products**
  - Concrete Ties
  - Plastic/Composite Ties
# Assumptions

<table>
<thead>
<tr>
<th>Description</th>
<th>Creosote</th>
<th>Concrete</th>
<th>Plastic/Comp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>7”x9”x8.5’</td>
<td>Same</td>
<td>Same</td>
</tr>
<tr>
<td>Avg. Life</td>
<td>35 yr</td>
<td>40 yr</td>
<td>40 yr</td>
</tr>
<tr>
<td>Spacing c-c</td>
<td>19.5”</td>
<td>24”</td>
<td>19.5”</td>
</tr>
<tr>
<td>Weight</td>
<td>235 lb</td>
<td>700 lb</td>
<td>250 lb</td>
</tr>
<tr>
<td>Post use recycle</td>
<td>71% cogen</td>
<td>63% grind for aggregate</td>
<td>42% grind for plastic</td>
</tr>
<tr>
<td></td>
<td>12% landscape, farm, etc.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Creosote-Treated Ties - Assessment

### Assess for Complete Life Cycle – All Indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Creosote-treated tie</th>
<th>Concrete tie</th>
<th>Plastic/composite tie</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouse Gases</td>
<td>0.36</td>
<td>1.0</td>
<td>0.81</td>
</tr>
<tr>
<td>Fossil Fuel Use</td>
<td>0.40</td>
<td>0.76</td>
<td>1.0</td>
</tr>
<tr>
<td>Acid Rain</td>
<td>0.013</td>
<td>1.0</td>
<td>0.99</td>
</tr>
<tr>
<td>Water Use</td>
<td>0.10</td>
<td>0.84</td>
<td>1.0</td>
</tr>
<tr>
<td>Smog</td>
<td>0.42</td>
<td>1.0</td>
<td>0.49</td>
</tr>
<tr>
<td>Eutrophication</td>
<td>0.49</td>
<td>1.0</td>
<td>0.36</td>
</tr>
<tr>
<td>Ecological Toxicity</td>
<td>-0.036</td>
<td>1.0</td>
<td>0.33</td>
</tr>
</tbody>
</table>

- **Normalized max = 1**
- **Full product life cycle.**
### Creosote-Treated Ties – Assessment

Normalized Total Annual Insertions to U.S. Total Impacts or **Class 1 RR**

<table>
<thead>
<tr>
<th>Impact Indicator</th>
<th>As % of U.S. Total</th>
<th>As % of Class 1 RR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Creosote Wood Ties</td>
<td>Concrete Ties</td>
</tr>
<tr>
<td><strong>Greenhouse Gas</strong></td>
<td>0.017%</td>
<td>0.046%</td>
</tr>
<tr>
<td><strong>Emissions</strong></td>
<td>2.4%</td>
<td>6.6%</td>
</tr>
<tr>
<td><strong>Fossil Fuel Use</strong></td>
<td>0.022%</td>
<td>0.042%</td>
</tr>
<tr>
<td></td>
<td>3.1%</td>
<td>6.0%</td>
</tr>
<tr>
<td><strong>Acid Rain Potential</strong></td>
<td>0.001%</td>
<td>0.049%</td>
</tr>
<tr>
<td></td>
<td>0.03%</td>
<td>1.97%</td>
</tr>
</tbody>
</table>

None of these tie systems will have significant impact from a **U.S. perspective, but may be important to the railroads freight transport related emissions.**

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Creosote-Treated Tie LCA Conclusions

• Creosote-treated ties compare
  • Primarily favorable to plastic/composite ties
  • Favorable to concrete for all indicators
  • Favorable to P/C for total energy, GHG, fossil fuel, acid rain, water use, and ecological toxicity, but about equal for smog and less favorable for eutrophication.

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Creosote-Borate and CuNap-Borate Dual Treatment Technology
Some Species Have Thin Sapwood and Refractory Heartwood

- White Oak
- Black Gum
- Sweet Gum
- Red Oak
- Beech
Focus on available railroad and industry data on concrete crosstie performance under railway operations in US & Canada.
Tie Performance ---- 20 Years of Exposure in AWPA Hazard Zone 4

<table>
<thead>
<tr>
<th>Treatment $^a$</th>
<th>Wood Species $^b$</th>
<th>Exterior Rating $^c$</th>
<th>Interior Rating $^c$</th>
<th>Loose Spikes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>G</td>
<td>0</td>
<td>0</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td>RO</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>WO</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Creo</td>
<td>G</td>
<td>9.8</td>
<td>9.4</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>RO</td>
<td>8.6</td>
<td>8.5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>WO</td>
<td>8.5</td>
<td>8.0</td>
<td>0</td>
</tr>
<tr>
<td>CuNap</td>
<td>G</td>
<td>6.0</td>
<td>8.0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>RO</td>
<td>6.5</td>
<td>4.0</td>
<td>1</td>
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<tr>
<td></td>
<td>WO</td>
<td>7.0</td>
<td>5.7</td>
<td>0</td>
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<tr>
<td>TimBor</td>
<td>G</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>RO</td>
<td>2.0</td>
<td>1.1</td>
<td>2</td>
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<td></td>
<td>WO</td>
<td>3.0</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>TimBor-Creo</td>
<td>G</td>
<td>9.3</td>
<td>9.4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Ro</td>
<td>8.3</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>WO</td>
<td>8.8</td>
<td>9.6</td>
<td>0</td>
</tr>
<tr>
<td>TimBor-CuNap</td>
<td>G</td>
<td>8</td>
<td>9.7</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>RO</td>
<td>7.7</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>WO</td>
<td>7.2</td>
<td>8.8</td>
<td>0</td>
</tr>
</tbody>
</table>

$^a$ Creo = creosote, CuNap = copper naphthenate, Timbor = borate

$^b$ G = gum, Ro = red oak, WO = white oak

$^c$ Average rating using AWPA E7 scale (10 = no deterioration, 0 = failure)
Cordele February 2010

- Onsite to mark 23-year old ties for removal and destructive testing
Cordele February 2010

- Ties to be removed were numbered & anchors removed

Thin Sapwood and Difficult to Treat Heartwood
Cordele February 2010

• In preparation for the field trip the test ties removed from track were sectioned
Cordele February 2010

• On the day of the field trip 50 RTA members including most major railroads gathered to review the sectioned ties
Cordele February 2010

• Then sprayed the ties with borate sensing reagent
Cordele February 2010

- This illustrated that after 23-years borates remained in sufficient concentrations throughout the cross-section to provide efficacy against decay and termites
Then attendees walked the track to see for themselves.
Cordele February 2010

- Note borates inhibited iron degradation of the spikes
Cordele February 2010

• Conclusions

  – All the test ties removed and all test remaining in track showed normal wear for 23 years in track
  – None showed visible signs of significant decay
  – Some Creosote-only ties that had been installed as recently as 2000 were decayed to the point replacement would occur in next tie cycle
  – No reason to suspect that the failure mechanism for test ties will ever be decay or insect damage
  – Dual treatment technology extends the life of refractory a minimum of 20-30 years in Zones 4/5
Economic Analysis of Dual Treatments

- RTA studies have shown that dual treatment with creosote and borate can lead to a significant extension of wood tie life, particularly in areas where environmental decay is the primary factor in tie failure.

- This presentation explains the projected life extension in the US based on dual treatment, and the economic benefit of dual treatment.
Current US Average Tie Life

- Based on 5-year history of tie replacements

<table>
<thead>
<tr>
<th>Year</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Track Miles</td>
<td>162,056</td>
<td>161,114</td>
<td>160,734</td>
<td>160,781</td>
<td>160,781</td>
</tr>
<tr>
<td>Ties*</td>
<td>526,557,342</td>
<td>523,496,566</td>
<td>522,261,858</td>
<td>522,414,572</td>
<td>522,414,572</td>
</tr>
<tr>
<td>Wood Ties**</td>
<td>500,229,474</td>
<td>497,321,738</td>
<td>496,148,766</td>
<td>496,293,844</td>
<td>496,293,844</td>
</tr>
<tr>
<td>Ties Installed</td>
<td>14,017,000</td>
<td>13,464,000</td>
<td>14,401,000</td>
<td>14,463,000</td>
<td>14,292,000</td>
</tr>
<tr>
<td>Tie Life (years)</td>
<td>35.7</td>
<td>36.9</td>
<td>34.5</td>
<td>34.3</td>
<td>34.7</td>
</tr>
<tr>
<td>5-year Average of US Tie Life</td>
<td>35.2</td>
<td>35.2</td>
<td>35.2</td>
<td>35.2</td>
<td>35.2</td>
</tr>
</tbody>
</table>

*Based on 3249 ties per mile
**Based on US ties being 95% wood and 5% other materials
Climate Zones for Severity of Wood Decay

- Dual-treatment to be used primarily in zones with most severe wood decay (Zones 5, 4, and 3)
# Wood Ties by Climate Zone

- Based on state-by-state totals of Class 1 “route miles” from AAR

<table>
<thead>
<tr>
<th></th>
<th>All US</th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
<th>Zone 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>US Route Miles</strong></td>
<td>139,679</td>
<td>27,195</td>
<td>28,702</td>
<td>39,278</td>
<td>30,263</td>
<td>14,241</td>
</tr>
<tr>
<td><strong>Dist. (%)</strong></td>
<td>100%</td>
<td>19.5%</td>
<td>20.5%</td>
<td>28.1%</td>
<td>21.7%</td>
<td>10.2%</td>
</tr>
<tr>
<td><strong>US Track Miles</strong></td>
<td>212,365</td>
<td>41,347</td>
<td>43,638</td>
<td>59,717</td>
<td>46,011</td>
<td>21,652</td>
</tr>
<tr>
<td><strong>Percentage Wood</strong></td>
<td>94.8%</td>
<td>90%</td>
<td>90%</td>
<td>98%</td>
<td>98%</td>
<td>98%</td>
</tr>
<tr>
<td><strong>Wood Ties</strong></td>
<td>654,131,564</td>
<td>120,911,350</td>
<td>127,610,939</td>
<td>190,153,628</td>
<td>146,510,350</td>
<td>68,945,298</td>
</tr>
</tbody>
</table>
## Tonnage and Curvature Distributions

- Estimates based on a variety of industry sources

### Tonnage Category

<table>
<thead>
<tr>
<th>Tonnage Category</th>
<th>Distribution (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Tonnage Main Lines (&gt; 50 MGT)</td>
<td>34%</td>
</tr>
<tr>
<td>Moderate Tonnage Main Lines (20 to 50 MGT)</td>
<td>19%</td>
</tr>
<tr>
<td>Secondary Track</td>
<td>25%</td>
</tr>
<tr>
<td>Yards</td>
<td>22%</td>
</tr>
</tbody>
</table>

### Curvature Category

<table>
<thead>
<tr>
<th>Curvature Category</th>
<th>Distribution (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tangent/Shallow (Tangent to less than 2°)</td>
<td>92%</td>
</tr>
<tr>
<td>Moderate (2° to less than 6°)</td>
<td>7%</td>
</tr>
<tr>
<td>Severe: (6° and above)</td>
<td>1%</td>
</tr>
</tbody>
</table>
### Creosote-Only Tie Lives

<table>
<thead>
<tr>
<th>Tonnage/Curve Category</th>
<th>Tan/Shal</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>38.6</td>
<td>34.7</td>
<td>28.1</td>
</tr>
<tr>
<td>Moderate</td>
<td>43.1</td>
<td>39.4</td>
<td>32.8</td>
</tr>
<tr>
<td>Secondary</td>
<td>46.1</td>
<td>42.9</td>
<td>37.0</td>
</tr>
<tr>
<td>Yards</td>
<td>49.0</td>
<td>47.0</td>
<td>43.3</td>
</tr>
<tr>
<td><strong>Weighted Average for Zone 1</strong></td>
<td><strong>43.3</strong></td>
<td><strong>43.3</strong></td>
<td><strong>43.3</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tonnage/Curve Category</th>
<th>Tan/Shal</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>35.5</td>
<td>32.0</td>
<td>26.0</td>
</tr>
<tr>
<td>Moderate</td>
<td>39.7</td>
<td>36.3</td>
<td>30.2</td>
</tr>
<tr>
<td>Secondary</td>
<td>42.5</td>
<td>39.6</td>
<td>34.2</td>
</tr>
<tr>
<td>Yards</td>
<td>45.1</td>
<td>43.3</td>
<td>40.0</td>
</tr>
<tr>
<td><strong>Weighted Average for Zone 2</strong></td>
<td><strong>39.9</strong></td>
<td><strong>39.9</strong></td>
<td><strong>39.9</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tonnage/Curve Category</th>
<th>Tan/Shal</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>32.0</td>
<td>28.8</td>
<td>23.4</td>
</tr>
<tr>
<td>Moderate</td>
<td>35.8</td>
<td>32.6</td>
<td>27.1</td>
</tr>
<tr>
<td>Secondary</td>
<td>38.3</td>
<td>35.6</td>
<td>30.7</td>
</tr>
<tr>
<td>Yards</td>
<td>40.6</td>
<td>39.0</td>
<td>36.0</td>
</tr>
<tr>
<td><strong>Weighted Average for Zone 3</strong></td>
<td><strong>35.9</strong></td>
<td><strong>35.9</strong></td>
<td><strong>35.9</strong></td>
</tr>
</tbody>
</table>

- Calculated with RTA’s *TieLife* based on tonnage, curvature, and climate zone factor
# Creosote-Only Tie Lives

## Tonnage/Curve Category

<table>
<thead>
<tr>
<th>Category</th>
<th>Tan/Shal</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>27.3</td>
<td>24.6</td>
<td>20.0</td>
</tr>
<tr>
<td>Moderate</td>
<td>30.6</td>
<td>27.9</td>
<td>23.3</td>
</tr>
<tr>
<td>Secondary</td>
<td>32.7</td>
<td>30.4</td>
<td>26.2</td>
</tr>
<tr>
<td>Yards</td>
<td>34.7</td>
<td>33.3</td>
<td>30.7</td>
</tr>
</tbody>
</table>

**Weighted Average for Zone 4**: 30.7

## Tonnage/Curve Category

<table>
<thead>
<tr>
<th>Category</th>
<th>Tan/Shal</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>16.1</td>
<td>14.6</td>
<td>11.8</td>
</tr>
<tr>
<td>Moderate</td>
<td>18.1</td>
<td>16.5</td>
<td>13.8</td>
</tr>
<tr>
<td>Secondary</td>
<td>19.3</td>
<td>18.0</td>
<td>15.5</td>
</tr>
<tr>
<td>Yards</td>
<td>20.5</td>
<td>19.7</td>
<td>18.2</td>
</tr>
</tbody>
</table>

**Weighted Average for Zone 5**: 18.1

## Climate Zone

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Average New Creosote-Only Tie Life (years)</th>
<th>Distribution (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>43.3</td>
<td>19.5%</td>
</tr>
<tr>
<td>2</td>
<td>39.9</td>
<td>20.5%</td>
</tr>
<tr>
<td>3</td>
<td>35.9</td>
<td>28.1%</td>
</tr>
<tr>
<td>4</td>
<td>30.7</td>
<td>21.7%</td>
</tr>
<tr>
<td>5</td>
<td>18.1</td>
<td>10.2%</td>
</tr>
<tr>
<td>System-wide US Average</td>
<td>35.2</td>
<td>100%</td>
</tr>
</tbody>
</table>
Life Extension with Dual-Treatment

- RTA studies have shown these life extension factors
- Reflects only environmental extension, not mechanical

<table>
<thead>
<tr>
<th>Treatability Group</th>
<th>Distribution</th>
<th>Climate Zone 5</th>
<th>Climate Zone 4</th>
<th>Climate Zone 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40.0%</td>
<td>2.8</td>
<td>2.5</td>
<td>1.7</td>
</tr>
<tr>
<td>2</td>
<td>17.5%</td>
<td>2.3</td>
<td>1.9</td>
<td>1.5</td>
</tr>
<tr>
<td>3</td>
<td>24.5%</td>
<td>1.6</td>
<td>1.4</td>
<td>1.2</td>
</tr>
<tr>
<td>4</td>
<td>18.0%</td>
<td>1.2</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Weighted Average</td>
<td>100%</td>
<td>2.1</td>
<td>1.9</td>
<td>1.4</td>
</tr>
</tbody>
</table>

*RTA studies have shown these life extension factors. Reflects only environmental extension, not mechanical.*

*Weighted Average for Climate Zone*
## Projected US Wood Tie Lives Based on Dual-Treatment in Zones 3, 4, and 5

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Creosote-Only</th>
<th>Dual-Treated</th>
<th>Percent Increase from Dual-Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>43.3</td>
<td>43.3</td>
<td>Not dual treated</td>
</tr>
<tr>
<td>2</td>
<td>39.9</td>
<td>39.9</td>
<td>Not dual treated</td>
</tr>
<tr>
<td>3</td>
<td>35.9</td>
<td>39.9</td>
<td>11.1%</td>
</tr>
<tr>
<td>4</td>
<td>30.7</td>
<td>39.9</td>
<td>30.0%</td>
</tr>
<tr>
<td>5</td>
<td>18.1</td>
<td>38.6</td>
<td>113.3%</td>
</tr>
<tr>
<td>US System-wide</td>
<td>35.2</td>
<td>40.4</td>
<td>14.8%</td>
</tr>
</tbody>
</table>

- Mechanical limit imposed whereby the dual-treatment life cannot exceed the life in Zone 2
Economic Benefit Analysis

• Year-by-year costs of continuing to replace failed ties with conventional creosote treated ties calculated
• Year-by-year costs of replacing failed creosote ties with dual-treated ties calculated
• All future costs expressed using “today’s dollars” or Net Present Value (NPV):
  \[ NPV = \frac{\text{Dollar Amount}}{(1 + i)^n} \]
  
  where: i is interest rate and n is number of years in the future
• Three interest rates examined: 3%, 6%, 10%
• Installed cost of creosote ties = $110.00
• Three cases of dual-treated tie cost: $115, $112.50, and $110
  – Lower cost achieved by making reductions to the amount of creosote used in the dual-treated ties
## Replacement Rate for Creosote-Only Ties

<table>
<thead>
<tr>
<th></th>
<th>Zone 5</th>
<th>Zone 4</th>
<th>Zone 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Wood Ties</td>
<td>68,945,298</td>
<td>146,510,350</td>
<td>190,153,628</td>
</tr>
<tr>
<td>Creosote-Only Tie Life (years)*</td>
<td>18.0</td>
<td>30.0</td>
<td>35.0</td>
</tr>
<tr>
<td>Replacement Ties Per Year</td>
<td>3,830,294</td>
<td>4,883,678</td>
<td>5,432,961</td>
</tr>
<tr>
<td>Cost Per Year at $110.00 Per Tie</td>
<td>$421,332,375</td>
<td>$537,204,616</td>
<td>$597,625,687</td>
</tr>
</tbody>
</table>

*Tie lives rounded down to nearest whole integer for analytical purposes
Conclusions

- Dual-treatments (Creosote-Borate & CuNap/Borate) have been shown to extend wood tie life, especially in the most severe decay zones (zones 3 thru 5).

- This analysis has shown that introduction of dual-treatment in zones 3, 4, and 5 would extend the US average wood tie life from 35.2 years to 40.4 years, an increase of 14.8%.

- In the most severe US climates, average tie life is ~18.5 years. With dual-treatment technology this could be extended to 35+ years.
Conclusions

- Economic benefit is clearly achieved in Zone 5 for all interest rates and dual-treatment costs.

- Economic benefit is achieved in Zone 4 with either interest rates below 10% or a dual-treatment cost increase of less than $5.00 over the base $110.00 creosote tie cost. At parity there are significant cost benefits in all three zones.

- Dual treatment in Zones 3, 4, and 5 would result in an economic benefit of 13 to 21 billion dollars (actual, not NPV). This would equate to 1 to 5 billion dollars in NPV depending on interest rates and dual treatment cost per tie.
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Videos

Here is the link to all of our videos:

Here are the videos in order:

About RTA's Tie Grading Seminar

Module 1 Wood ID Part 1
RTA as a Resource

www.rta.org

Disponible en español

Tie Guide
Tie Guide: Handbook for Commercial Timbers Used by the Crosstie Industry

The wood crosstie has served the American railroad industry as a foundation for the rail in the track structure. The crosstie is an exemplary. The information provided in this booklet will include treatment and ultimate use of wood in the engineered crosstie.

The Tie Guide is also available online.

Table of Contents
Introduction
The Treatment of Wood Crossties
Technical Aspects and a Lesson in Wood
A Brief History of Wood Preservation
Why should Wood be Treated with Preservative?
A Summary of Commercial Timbers Used as Crosstie Materials
The Engineered Wood Crosstie
Solid Sawn Material
Hybrid Engineered Combination Material

Appendix
Specification for Timber Crossties
American Wood-Preservers' Association Preservative Standards, P1/P13, P2, P3, and P4
American Wood-Preservers' Association Commodity Standard C6, "Crossties and Switch Ties"

References
The Conditioning & Treatment of Wood Crossties
Preparation of Crossties and Timbers for Treatment
Effect of Wood Structure on Treatment
Moisture Content and Its Effect on Treatment
Wood Preservative and the Pressure Processes
The Treatment Processes
Standards and Specifications for Treatment
Questions and Answers
About the Authors
Monthly Trends

Monthly Trends will allow you to examine a variety of different issues about which the RTA routinely collects information. Our intent is to supply industries such as the Class I Railroads, Short Line Railroads, Tie Production companies, Cross Tie Tying facilities, and many others with the latest purchase and production information available.

The Purchases Report contains monthly production and inventory data from 1987 to the current month for which RTA producers report. It also provides several key ratios, quarterly data, and select comparative data. Purchases are calculated based on the difference between monthly production and the change in inventory. This is the most important producer information that RTA uses in its econometric forecasting process for tie demand.

You can also try the RTA interactive spreadsheet to create your own scenarios for 2012 forecasts.

RTA Production (Trends) Report has undergone a revision. The Quick Glance report is a snapshot of regional log availability, sawn hardwood product market conditions, and a production outlook. The Reporters' Forum has recently been unveiled and is a members-only forum where a running commentary is available with in-depth information on what is occurring in the marketplace.

The Class I Tie Report contains monthly data submitted by Class I railroads on inventory and tie demand estimates from six US and Canadian Class I railroads. These data allow the reader to see how many ties (green and treated) the Class Is say they have committed compared to their estimates for demand over the ensuing 12-month period.

Tie Trends State Profile provides a look at the economic impact of both the forest products industry and the railroad industry in a selected US state. This information is helpful when explaining the importance of these two vital industries to a state or national elected or appointed official. If your state is not the state currently profiled, you may contact RTA for that information at www.rta.org.
RTA as a Resource

www.rta.org

Resources

Online Publications

The RTA offers numerous publications and visual media for sale.

In addition, many publications are available online to download at no charge. Click on a category below to learn more about these publications.

- Tie Basics
- Crossties Magazine
- Research Papers and Articles
- Environmental
- RTA Specifications and Visual Guide to Tie Defects
- Tree to Track Poster
- Tie Defect Poster
- Tree to Track Presentation
Summary

- Wood tie performance is well documented and still used in 94% of all US and Canadian track applications.
- Concrete tie performance issues suggest lower life in track than expected.
- Maintenance in situ for concrete ties is expensive and prevalent.
- Wood outperforms alternative ties in ELCA performance and GHG emissions.
- While using one preservative in areas of high biological hazards provides satisfactory performance, new preservative technologies can significantly increase life-in-track performance for all wood species and potentially reduce GHG emissions.