RTA TieReport #10

Comparison of Tie Requirements as a Function of Inspection Technique

The two most common techniques for monitoring tie condition in railroad use are traditional visual inspection (using either a mechanical counter to summarize total bad ties per mile or the TieInspect tie condition recording and mapping system to record the condition of each tie) and lateral track strength measurement using a track strength measurement vehicle such as the Gage Restraint Measurement System (GRMS) mounted on either a railbound or hi-rail vehicle.

Since the track strength measurement system focuses on (and measures) the lateral strength of the track, the question often arises as to whether the track strength measurement system identifies the same ties or different ties than a good tie inspector. This report compares the replacement tie requirements using the two different tie inspection techniques; visual inspection with the tie condition data recorded by ZETA-TECH's TieInspect system, and track strength vehicle-based inspection using a hi-rail inspection vehicle and a railbound GRMS vehicle. Over a million ties (320 miles) of data were utilized for this study on three separate subdivisions over two different railways. As such, differing maintenance strategies and tonnages are reflected as part of this study.

Table 1: Tie Condition Threshold for GRMS Data

Tie Condition	GWP Range
Good	< 0.5
Marginal	0.5 to 0.75
Bad	0.75 to 1.0
Failed	> 1.0

The tie condition data were gathered by railroad tie inspectors using TieInspect units, and the GRMS data were collected by both a hi-rail inspection vehicle and a railway-owned GRMS vehicle. These data were analyzed to determine the number of good, marginal, bad, and failed ties. This tie condition information was input directly by the tie inspectors using railroad criteria for each of the four categories. In the case of the GRMS based data, the Gage Widening Projection, or GWP, was used as the basis of analysis using the criteria shown in Table 1.

[1] *Holland's TrackStar vehicle*
[2] *Holland's TrackStar vehicle*

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In addition to the raw count of tie condition, the projected number of replacement ties was also determined and used as a basis of comparisons. Two separate replacement strategies were considered:

- Replacement of all bad and failed ties
- An optimized replacement strategy that selectively replaces ties to leave a defined condition in track, thus leaving some bad ties in track and replacing some marginal ties.

Data Analysis

As noted above, condition data for over a million ties (320 miles of track) were analyzed. These data came from three separate subdivisions over two different railways and were used to identify the differences in required replacement ties based on the two different inspection approaches together with a consolidated approach. Specifically, the following replacement and inspection analyses were conducted:

- **Inspection**
  - Visual Inspection Utilizing TieInspect
  - Lateral Track Strength Utilizing GRMS
  - Overlaying and Combining TieInspect and GRMS

- **Replacement Methodology**
  - Replacement of All Bad and Failed Ties
  - Optimized Replacement Strategy Leaving a Defined Condition in Track

The summary tie condition data in Table 2 show the number of ties by condition (as well as percentages) for the TieInspect and GRMS inspections. Also shown is the condition that results when the two data sets are combined using the worst case condition for each tie. Combining the two data sets in this manner allows for the inclusion of laterally weak locations that an inspector may not readily find through visual inspection, while preserving the conditions identified due to all other non-lateral failure modes[3].

Table 2: *Summary Tie Condition Data*

	Good	Marginal	Bad	Failed
TieInspect	441,595	353,260	221,616	24,729
GRMS	703,115	322,583	13,778	1,724
TI/GRMS	307,174	476,716	230,981	26,329
TieInspect	42 %	34 %	21 %	2.4 %
GRMS	68 %	31 %	1.3 %	0.2 %
TI/GRMS	30 %	46 %	22 %	2.5 %

It can be seen from these data that the distribution of ties by condition varies significantly by inspection method. This is illustrated in Figure 1.

[3] *GRMS measurements focus on lateral gauge-holding strength of the ties*

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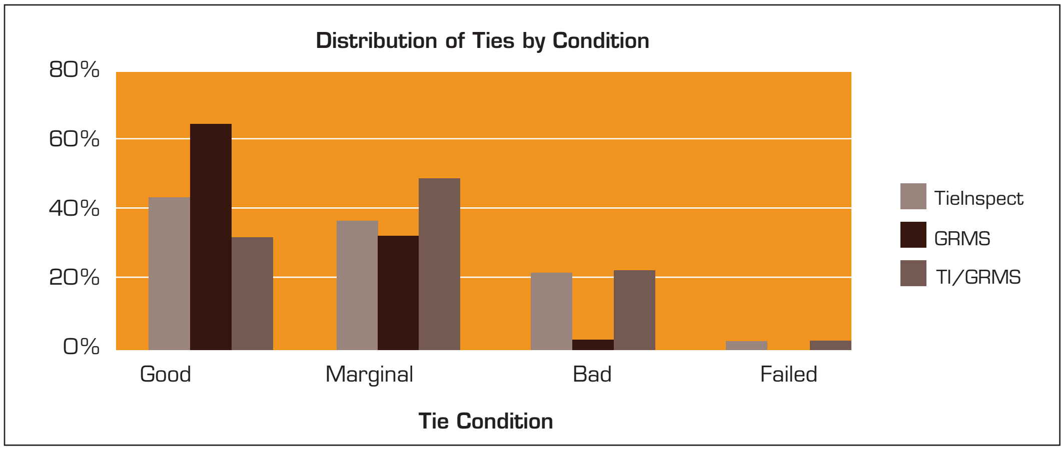
Figure 1: Percentage of Ties by Condition



As can be clearly seen from Table 2 and Figure 1, the visual TieInspect technique captures the vast majority of the bad and failed ties. The track strength (GRMS) inspection alone does not pick up the majority of bad and failed ties. That is because GRMS identifies laterally weak spots and not individual "bad" ties in track. It also does not address other failure modes, such as vertical strength-related tie conditions. However, GRMS inspection does identify additional strength-degraded ties that the visual inspection does not pick up. While relatively small, on a percentage basis, a significant number of these additional ties are in the "Bad" and "Failed" categories.

As can be seen from Table 2, overlaying and combining the two inspection methodologies results in the maximum number of bad and failed tie costs. Overall, GRMS increased "failed" tie count by approximately 1,600 ties (from 2.4% to 2.5%) and "bad" tie count by approximately 9,400 ties (from 21% to 22%). Thus, the addition of the GRMS inspection data to the visual (TieInspect) data enhances the effectiveness of the tie inspection and corresponding replacement process.

In order to better examine the alternate inspection techniques, two different tie replacement strategies were also examined. The first was simply replacing all bad and failed ties; the alternate was an optimized replacement methodology that selectively replaces ties based on a distribution of conditions. The optimized replacement methodology uses tie replacement logic developed by ZETA-TECH and a major railroad that defines tie replacement criteria based on number of adjacent good and/or marginal ties, proximity to a switch, bridge, or crossing, and other parameters such as track class (speed), curvature, etc. This tie replacement logic then identifies the specific ties to be replaced.

Table 3 presents a side-by-side comparison of ties to be replaced for the two replacement methodologies and the three data sets. As can be seen from these tables, there is a significant difference in the number of ties to be replaced for the three different sets of data. As noted previously, the tie inspector identifies more degraded ties than GRMS. However, the inspector may not always be able to identify track strength-related weak spots, which is effectively done by a GRMS-based measurement. Thus, the two inspection methodologies are not exclusive of one another and can be overlaid to provide a more comprehensive set of tie condition data, as shown in Table 2.

As can be seen in Table 3, the optimized replacement method reduces the number of ties to be replaced from the total of bad and failed ties. That is because some of the bad ties (not failed) are left in track, and some of the marginal ties are replaced as well, in order to leave a defined condition in track. This effectively extends the life of some ties, optimizes replacements, and results in some economic savings that allow for the optimal distribution of resources. As shown in Table 3, the optimized replacement logic results in 24% of the ties being replaced, as opposed to 24.7% when all of the bad and failed ties are replaced. This is a savings of over 7,600 ties or approximately 3% of the ties to be installed.

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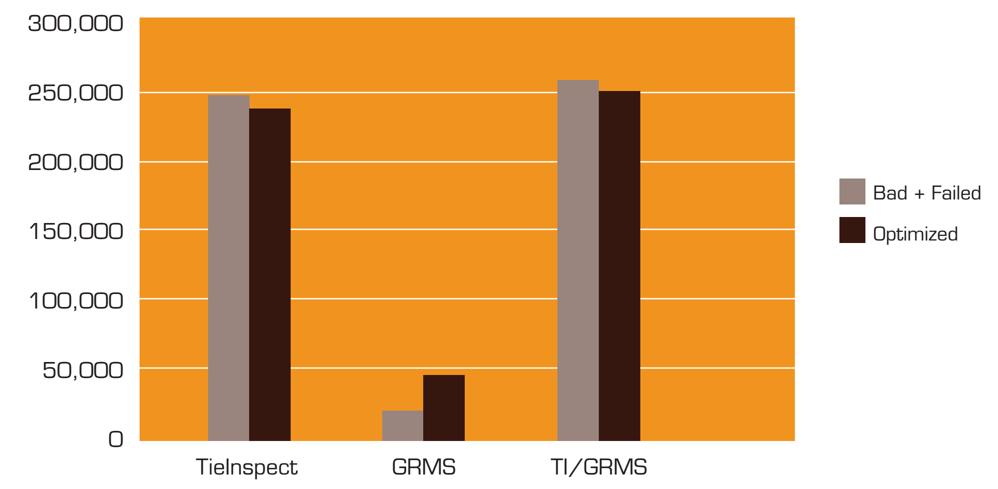
Table 3: Alternate Replacement Strategies

	All Bad and Failed	Optimized Tie Replacements
TieInspect	246,345	234,918
GRMS	15,502	44,222
TI/GRMS	257,310	249,677
TieInspect	23.7 %	22.6 %
GRMS	1.5 %	4.2 %
TI/GRMS	24.7 %	24.0 %

Figure 2 graphically displays the replacement tie requirements for the three inspection techniques/data.

Figure 2: Tie Replacement Requirements-All Sites



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