Report Of A Field Demonstration: Use Of Track Strength Data To Optimize Tie Replacement Requirements

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In recent years, track strength measurements have proven their value in locating weak spots in the track, and the use of track strength measurement vehicles have become a part of normal railroad track inspection practices. However, the use of this data in planning tie maintenance and in scheduling tie replacements has been limited. This article presents the results of a collaborative effort between the Federal Railroad Administration (FRA), the Railway Tie Association (RTA), CSX Transportation and ZETA-TECH Associates Inc. to use track strength data to optimize crosstie upgrade and maintenance practices. Specifically, the focus of this study was to compare tie replacement strategies based on conventional visual inspections to those based on track strength measurements taken from Gage Restraint Measurement System (GRMS) inspection data.

This study made use of a full-scale field demonstration for a side-by-side comparison of alternate upgrade and maintenance approaches. Specifically, GRMS[1], conventional[2] and *TieInspect*™ [3] based approaches were compared. The test zone consisted of four test miles, each with a unique upgrade and maintenance combination, as shown in *Table 1*. Note the test zone was FRA Class 4 with a mix of freight and high-speed passenger operations (79 mph passenger speed) and was predominantly tangent track (with some limited curvature).

In the case of the GRMS upgrade (and maintenance) miles, GRMS data was used as the basis for defining which ties were to be replaced. Tie replacement was then performed by conventional CSX tie gangs according to the GRMS-based tie replacement plan. In the case of the conventional upgrade (and maintenance), normal CSX tie spotting and replacement practices were followed.

Analysis of the GRMS track strength data, and specifically the Gage Widening Ratio[5] (GWR), showed that the average or mean GWR was representative of the track strength across each one-mile test zone and was used as the basis for this evaluation of alternate tie replacement strategies.

Using the GWR results, the pre-upgrade and post-upgrade performance of the GRMS and conventional upgrade test miles were evaluated, as shown in *Figure 1*.

Table 2 below summarizes the post-upgrade behavior of the GRMS track upgrade sections as compared to the conventional upgrade section.

As shown in *Table 2*, the GRMS miles outperformed the conventional mile in the effectiveness of the tie replacement/upgrade as defined by the corresponding mean GWR degradation rate. The lowest degradation rate corresponded to the GRMS upgrade mile (Mile 23) with the lowest number of ties installed (356 vs. 838 for the conventional mile). In addition, examination of the GWR standard deviation shows that the GRMS miles had higher pre-upgrade standard deviations, which indicates a wider scatter of tie condition, but ended up with lower standard deviations (less scatter) after the upgrade. This highlights the ability of the GRMS-upgrade approach to provide a more uniform, stronger condition based on the gage strength of the track. ▶

Table 1 — Test Miles & Corresponding Upgrade/Maintenance Approaches

MP	UPGRADE	UPGRADE TIES INSTALLED	MAINTENANCE	MAINTENANCE TIES INSTALLED
10	*TieInspect*[4]	888	*TieInspect*[4]	184
21	GRMS	878	GRMS	162
22	Conventional	838	Conventional	352
23	GRMS	356	Conventional	551

Figure 1
GWR with Upgrade Condition Interpolated

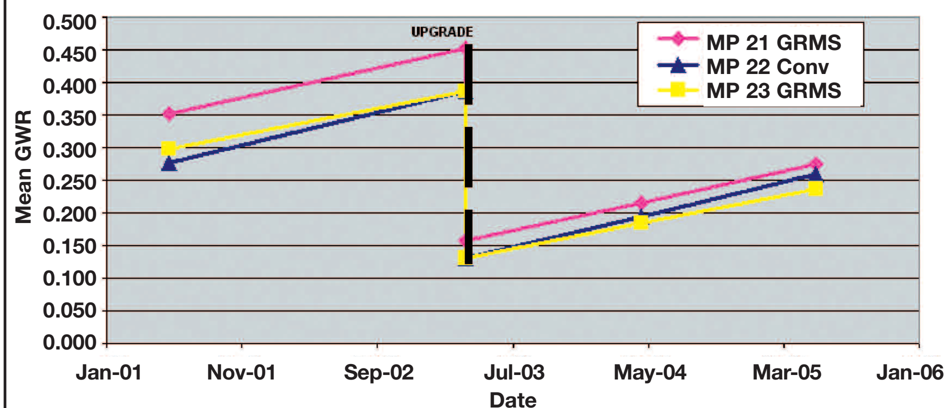

Table 2 — Post Upgrade Comparison of GRMS vs. Conventional Tie Installation

MP (Upgrade)	MEAN GWR (in.)		DEGRADATION RATE (in./yr.)	UPGRADE MAINTENANCE
	MAY-04	JUN-05		
21 (GRMS)	0.216	0.275	0.054	878
22 (Conv)	0.195	0.260	0.060	838
23 (GRMS)	0.184	0.237	0.049	356

In addition, although the conventionally upgraded mile (Mile 22) started off (pre-upgrade) with the best gage strength, it was outperformed after the upgrade by the GWR miles, particularly MP 23 (*Figure 1*). This is in spite of the fact that MP 23 had 58 percent fewer crossties installed. The other GRMS mile, MP 21 (GRMS), registered the largest improvement in mean GWR, again due to successful targeting of weak spots.

The effect of these relative degradation rates on the time it takes for the track to reach the GWR tie replacement threshold levels was also calculated. The results are presented in *Figure 2* at right. Note, the second or maintenance level used is the FRA-defined value of 0.75 inches[6]. A GWR value between 0.75 and 1 inch represents a second level exception and track speed must be set at the maximum for Class 3 track. A GWR reading of 1 inch or more represents a first level exception and track speed is to be reduced to 10 mph. Noting the above, the conventional mile on average reaches a second level exception 2.8 years earlier than the best performing GRMS mile. This is a direct function of the higher degradation rate shown above. By averaging the two GRMS mile degradation rates and using the second level exception threshold, it can be shown that the GRMS upgrade approach provides an additional 2.1 years to reach the threshold. Extending this improvement to overall tie life, and noting average tie life for this location is 23 years[7], this would represent a 9.1 percent extension in tie life.

In addition to the GRMS vs. conventional tie installation comparison, MP 10 employed the *TieInspect* system and replacement logic for both the upgrade and maintenance cycle. CSX inspectors graded the ties according to CSX standards and a full tie condition "map" was obtained and subjected to the *TieInspect* tie replacement logic model. Compared to the conventional CSX tie replacement approach, tie requirements were reduced by 9.8 percent using the *TieInspect* system and replacement logic.

In a manner similar to the upgrade results, the GRMS maintenance mile outperformed the conventional maintenance miles in average GWR improvement, with fewer ties installed. *Table 3* shows the direct comparison of average GWR improvement (From June 2005 to April 2006) and the number of ties installed for the maintenance cycle. The GRMS replacement methodology was once again successful in targeting and reducing GWR peaks while using fewer ties in the process[8].

Figure 2
Projected GWR Over Time

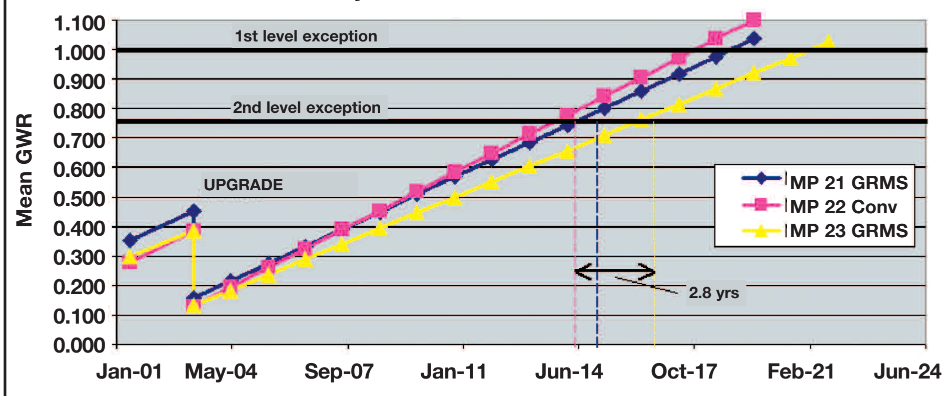

Table 3 — GWR Maintenance Results

MP	MAINT	AVG. GWR IMPROVEMENT	TIES
21	GRMS	0.046	162
22	Conv	0.030	352
23	Conv	0.019	551

Results

In total, 4,209 crossties were installed in this study over a five-year period, which included three years of monitoring with the CSX GRMS inspection vehicle. Results showed that GRMS-based tie replacement generated a stronger track structure with a lower rate of track strength degradation than conventional techniques while using fewer ties. That is because targeted tie replacement resulted in superior lateral track strength and decreased lateral degradation rates with an overall extension in the time to GRMS thresholds.

The concurrent economic analysis, extrapolating the performance of these test miles over the full CSX system, indicated that strategic tie replacement could reduce CSX tie costs on the order of $25 million to more than $30 million annually. It should be noted, however, that the observed improvements will vary mile to mile with different track characteristics such as tonnage and curvature. §

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Footnotes

1 Using the CSX GRMS (Gage Restraint Measurement System) test vehicle.
2 Based on current CSX tie replacement practices.
3 Using ZETA-TECH's TieInspect tie management system. Note, this was a secondary test and not the primary focus of the field test.
4 Secondary test.
5 GWR = (Loaded gage - Unloaded gage)*16,000/Lateral Gage Widening Load.
6 FRA Track Safety Standards, CFR Title 49 Part 213.110.
7 Average tie life was calculated using the RTA SelecTie Model II for the track and operating conditions of the Metropolitan Sub.
8 While the number of maintenance ties for MP 23 was high, the total upgrade plus maintenance ties for this mile was still well below the conventional tie mile total.