RTA TieReport #4

Optimizing Tie Maintenance Using Track Strength Information

During the last several decades, the introduction and growing use of lateral track strength measurement techniques has led to a better understanding of the gage holding strength condition of track [1,2,3]. This in turn has led to the development of standards and procedures for monitoring track strength from inspection vehicles and identifying locations of potential weakness of the track structure [3,4]. It has also led to a better understanding of the potential for using these track strength data to determine tie replacement requirements and to better manage the tie replacement process [5].

A recent major study, directed by the Railway Tie Association and performed in conjunction with the Federal Railroad Administration, CSX Transportation, and ZETA-TECH Associates, Inc., examined the potential for optimizing crosstie upgrade and maintenance practices by using track condition information. Specifically, the focus of this study was to compare tie replacement strategies based on conventional visual inspection with strategies based on objective tie condition measurements. Thus, the existing visual inspection and tie replacement practices of CSX were compared to one based on measured track strength values, as taken by CSX's Track Geometry Car mounted Gage Restraint Measurement System (GRMS) [6]. A third set of replacement strategies, based on the TieInspect data collection and analysis system, was also examined [7].

This comparison was conducted on four test miles on CSX, near Washington, DC, all FRA Class 4 track with both freight and passenger operations (79 mph passenger speed). Each test mile had tie upgrade (major replacement) and tie maintenance activities based on one of the above defined approaches:

- Conventional visual inspection and tie selection
- GRMS-based tie selection[1]
- TieInspect-based tie selection

The actual number of ties installed as part of either the upgrade or maintenance activities is presented in Table 1 for each of the four miles and associated maintenance approaches.

Table 1: *Test Miles and Corresponding Upgrade/Maintenance Approaches*

MP	Upgrade	Upgrade Ties Installed	Maintenance	Maintenance Ties Installed
10	*TieInspect*	888	*TieInspect*	184
21	GRMS	878	GRMS	162
22	Conventional	838	Conventional	352
23	GRMS	356	Conventional	551

[1]The GRMS location data were supplemented by tie-specific TieInspect data to allow for accurate location of specific ties.

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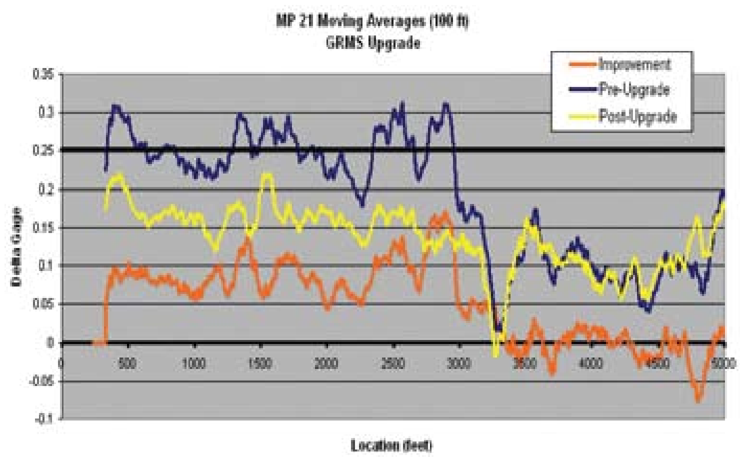
The strength of the track was used as a measure of the track condition, both before and after tie replacement. The measurement used to represent the track condition (strength) was the GRMS-based Gage Widening Ratio (GWR), which is related to the amount of rail head lateral movement (gage widening) under the applied GRMS loading. Analysis of GRMS data showed that the average or mean GWR is representative of the track strength across each test zone (one mile each) and thus formed the basis for evaluation of tie replacement performance.

Figure 1 illustrates the effect of the tie replacement during the upgrade of one of the test miles (MP 21). As can be seen in this Figure, there was a distinct improvement in measured track strength (GWR), particularly in the first 3500 feet where the majority of the ties were installed.

Figure 1: Improvement in Track Strength Due to Selective Tie Replacement



By comparing the rate of track degradation, both before and after the upgrades, for the different test sections, the relative effectiveness of the upgrades (and maintenance cycles) could be evaluated. Table 2 summarizes the behavior of the two GRMS track upgrade sections as compared to the conventional upgrade section, looking at mean GWR after upgrade.

Table 2: Post-Upgrade Comparison of GRMS vs. Conventional Tie

	Mean GWR (in.)		Degradation Rate	
MP (Upgrade)	May '04	June '05	in./yr.	Upgrade Ties
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

Installation

As can be seen 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 (best-performing track) corresponds to the GRMS upgrade mile (Mile 23) with the lowest number of ties installed; 356 vs. 838 for the conventional mile. Furthermore, 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 (more uniform) after the upgrade. This illustrates the ability of the GRMS-based upgrade approach to provide a more uniform, stronger condition, based on track gage strength.

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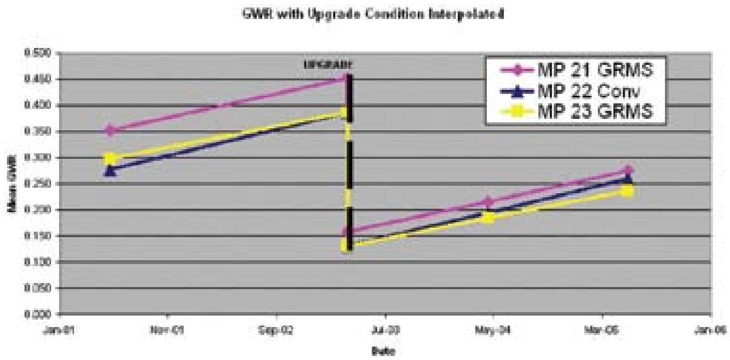
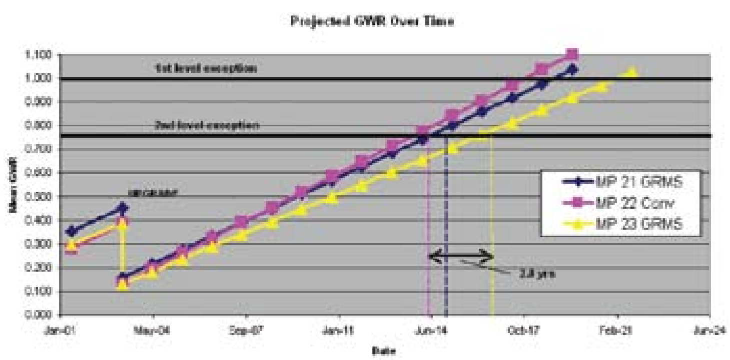
Figure 2 presents the relative behavior of the three test miles graphically. As can be seen in this Figure, the conventionally upgraded mile (Mile 22) started off (pre-upgrade) with the best gage strength, as defined by mean GWR, but was outperformed by the GRMS miles, particularly MP 23. This is in spite of the fact that MP 23 had 58% 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.

Figure 2: Mean GWR as a Function of Traffic and Upgrade



The effects of these relative degradation rates on the time it takes for the track to reach the GWR threshold levels was calculated and presented in Figure 3 below. Note, the threshold used is the FRA's second-level exception, which can be considered a maintenance limit of 0.75 inches. A GWR value between 0.75 and 1 inch represents a second-level exception and track speed must be set at the maximum allowed for class 3 track (*FRA Track Safety Standards Part 213, pg. 38*). A GWR reading of 1 inch or more represents a first-level exception and track speed is to be reduced to 10 mph (*FRA Track Safety Standards Part 213. pg. 37*). 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 was seen that the GRMS upgrade approach provided an additional 2.1 years to reach the threshold. Extending this improvement to overall tie life, and noting average tie life for this location was 23 years[2], this represents a 9.1% extension in tie life.

Figure 3: Projected GWR Over Time



[2]Average tie life was calculated using the RTA SelecTie Model II, for the track and operating conditions of the Metropolitan Sub.

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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. Inspectors looked for all tie failure mechanisms including the ties' ability to hold line and surface, splitting, breaks, plate cutting, plate movement, wheel cuts, decay or hollowness, and the ability to hold cut spikes. The inspections provided a full condition map and allowed for strategic tie replacement. Comparing this approach, using the *TieInspect* tie replacement logic and data, to the conventional CSX approach, tie requirements were reduced by 9.8% using the *TieInspect* system and replacement logic.

Maintenance ties were installed in October 2005 with a post-maintenance GRMS run conducted in April 2006. Similar to the upgrade findings, the GRMS maintenance mile outperformed the conventional maintenance miles in average GWR improvement, with much 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.

Table 3: GWR Maintenance Results

MP	Maintenance	Average GWR Improvement	Ties
21	GRMS	0.046	162
22	Conventional	0.030	352
23	Conventional	0.019	551

In total, over a 5-year test period, 4,209 crossties were installed in this study. 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 GRMS-based tie replacement generated a stronger track structure than conventional techniques, while using fewer ties, using its more targeted tie replacement. The GRMS test miles also showed a lower degradation rate with a lower number of upgrade ties installed; as compared to the conventional mile, with an overall extension in tie life. The GRMS miles had the lowest total ties (upgrade plus maintenance) installed (907 vs. 1,190) yet provided a more uniform, superior condition, based on the lateral gage strength of the track. An economic analysis of the benefits of strategic tie replacement showed that using a GRMS- or TieInspect-based tie replacement strategy can reduce system tie costs on the order of $27 to $47 million annually.

REFERENCES

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