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Crossties

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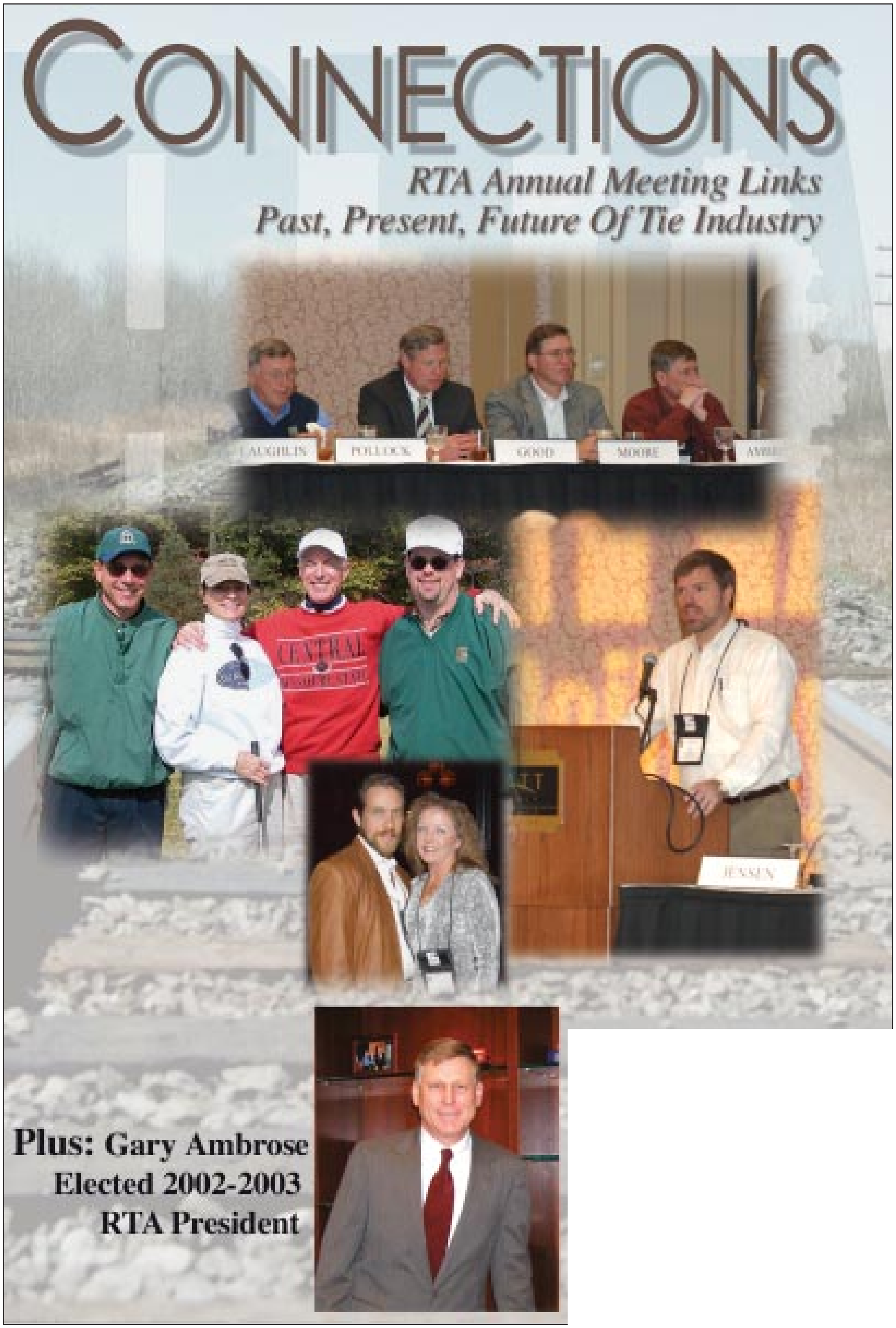

Special Reports

Field Demonstration Of The Use Of Track Strength Data To Optimize Tie Replacement Requirements For High-Speed Operations

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Editor's Note: Grissom and Palese, both of ZETA-TECH Associates, presented the following paper at the 2002 RTA Convention held Oct. 15-18, in St. Louis.

What is the most cost-effective approach for installing crossties? Where to install them, on what schedule and how many to install are all key issues to asset management. To help answer these questions, a field study, sponsored by the Federal Railroad Administration (FRA), was started last fall to perform a "side-by-side" comparison of alternate tie maintenance techniques. The FRA, Railway Tie Association (RTA), CSX Transportation and ZETA-TECH Associates have begun a collaborative effort to evaluate tie upgrade and maintenance methodologies utilizing track strength data in order to further understand the optimal and most cost-effective strategy.

In 1998, ZETA-TECH and the RTA performed a comprehensive study titled "Demonstration of High Speed Track Strength Maintenance Using Objective Gage Strength Data" for FRA's Office of High Speed Rail. This study examined several of the key background issues involved in the use of track strength measurement data from a lateral track strength vehicle to define tie replacement requirements for both conventional and high-speed track. This project laid the groundwork for the current study.

It is the goal of this study to upgrade and maintain 10 one-mile test sites utilizing different tie replacement philosophies. The test miles will experience similar field characteristics, including tonnage, curvature, speed and track strength data. After three years of monitoring and analyzing track condition, a life cycle costing analysis will be performed. This will include relative degradation, condition and cost (based on the number of ties required) to better understand the impacts of this study.

Task 1: Test Design

The study was designed based on two crosstie replacement issues of current interest: (1) to provide a direct comparison of alternate maintenance approaches and (2) to address the issue of track upgrade costs and the corresponding reduction in maintenance. To effectively address these issues, it was decided that 10 one-mile test sites were needed, with separate upgrade and maintenance philosophies for each. To broaden the study, five test miles would be on high-speed (79 mph), low-curvature zones (test sites 1-5), and five miles would be on lower-speed, high-curvature areas (test sites 6-10). Table 1 shows the complete test design for the project.

Table 1. Test Mile Selection

TEST SITE	MP	UPGRADE	MAINTENANCE
1	20	None	GRMS
2	21	GRMS	GRMS
3	22	Conventional	Conventional
4	23	GRMS	Conventional
5	28	None	Conventional
6	70	None	Conventional
7	79	Conventional	Conventional
8	82	*TieInspect*	*TieInspect*
9	83	Conventional	GRMS
10	84	Conventional	undecided

To fully understand the test design, the following definitions describe each upgrade and maintenance technique.

Upgrades

"None" or "as is" means no initial tie upgrade will be provided. These test miles will undergo cyclical tie maintenance only.

"Conventional" upgrades will be performed based on conventional CSX tie replacement strategy.

The Gage Restraint Measurement System (GRMS) upgrade will be based solely on lateral track strength data from CSX's GRMS vehicle. Locations exceeding a defined Gage Widening Ratio (GWR) will have ties "spotted" in. GWR is used because it is sensitive primarily to track strength. By design, it is not sensitive to wide gage as can be seen by the following equation typical of track strength inspection vehicles:

$$GWR = \frac{(LTG - UTG) * 16{,}000}{L}$$

where *LTG* is the loaded track gage, *UTG* is the unloaded track gage, and *L* is the laterally applied GRMS load. Projected Loaded Gage (PLG24) is not used for tie replacement, as it is sensitive to both rail gage face wear and weakened track strength.

The *TieInspect*™ upgrade is based on ZETA-TECH's *TieInspect*™ replacement logic, which is dependent upon track class and curvature. Each test mile will have a tie-by-tie condition report, which is collected using ZETA-TECH's *TieInspect*™ unit. This logic utilizes the collected data and strategically breaks up bad clusters while assuring adequate replacement in the vicinity of bridges, crossings and turnouts. Thus, not all bad ties are replaced; only those ties required to maintain track integrity are replaced.

Maintenance

Conventional maintenance will consist of tie spotting and replacement in accordance with current CSX standards and practices.

On GRMS maintenance miles, locations that exceed a defined GWR threshold will have ties "spotted" in to bring within tolerance (every six months). The maintenance threshold and upgrade thresholds will be different, as the upgrade threshold brings the test mile to a tighter standard initially.

The *TieInspect*™ maintenance is based on inspections every six months, where the new tie condition data will be evaluated and a tie-by-tie replacement plan will be generated from the logic.

Table 2. Test Site Status

TEST SITE	MP	UPGRADE	MAINTENANCE	MARKED	UPGRADE STATUS
1	20	None	GRMS	n/a	n/a
2	21	GRMS	GRMS	y	3%
3	22	Conventional	Conventional	y	18%
4	23	GRMS	Conventional	y	32%
5	28	None	Conventional	n/a	n/a
6	70	None	Conventional	n/a	n/a
7	79	Conventional	Conventional	y	100%
8	82	*TieInspect*	*TieInspect*	y	100%
9	83	Conventional	GRMS	y	100%
10	84	Conventional	undecided	y	100%

Task 2: Pre-Test Analysis And Inspection

Once the test design was developed, an appropriate line to perform the study had to be selected by the team. The test line needed the following characteristics: passenger carrying, high speed, uniform traffic and maintenance history, near middle of the tie gang cycle, tie gang in vicinity, and consistent GRMS vehicle runs.

Noting these attributes, the CSX Metropolitan and Cumberland subdivisions were selected as the test lines for the study. In an effort to narrow these lines down to 10 test miles, CSX provided track charts, curvature data, tonnage data, tie gang schedules, GRMS runs and passenger train schedules for these lines.

Task 3: Selection Of Test Sites And Detailed Tie Inspection

From each subdivision, five test miles had to be selected with similar speed, tonnage, curvature and tie gang cycle, while having consistent GRMS data from the last two runs. To aid in test site selection, a mile-by-mile database was compiled using CSX track data and GRMS analyses. Several GRMS vehicle runs were analyzed for GWR data consistency and relative rates of degradation as shown in Figures 1 and 2. Figure 1 shows a foot-by-foot record of two GWR runs over a potential test mile with excellent correlation. Figure 2 plots mean GWR (for the mile) for two runs over all potential test miles. This was useful in determining both consistency and relative degradation between runs.

After assembling and analyzing the data from both subdivisions the candidate test miles were chosen. The selected test miles from the CSX Metropolitan and Cumberland Subdivisions are listed below:

CSX Metropolitan Subdivision

- 5 Test Sites (Track 2, MP 20, 21-23, 28)
- High speed (79 mph passenger)
- Low curvature (mostly tangent miles)
- 64 annual MGT
- Last large tie gang 1993

CSX Cumberland Subdivision

- 5 Test Sites (Track 2, MP 70, 79, 82-84)
- Low speed (45 mph)
- High curvature (5-7 degree curves)
- 90 annual MGT
- Large tie gang this year

The assigned upgrade and maintenance methodology for each test mile is given in Table 1. To establish the current condition of the test miles, each was visually inspected using *TieInspect*™. A tie-by-tie condition report was generated for each mile, which was also useful in upgrading both the *TieInspect*™ and GRMS miles.

Task 4: Upgrades Of Test Sites

To perform an upgrade based on GRMS data it is necessary to locate specific ties based upon foot-by-foot data output. The *TieInspect*™ unit gave the test mile inspector the ability to record the start and end of curves within a test mile. By overlaying the GRMS superelevation channel with the *TieInspect*™ recorded curves as shown in Figure 3, a functional relationship was established between the "foot counter" of the GRMS vehicle and the *TieInspect*™ tie number. This produces the plot shown in Figure 4, which displays a more useful relationship of GWR versus tie number. Using a GWR upgrade threshold of 0.25 and the locating procedure described above, MPs 21 and 23 were marked using track strength data exclusively.

The other miles in the study were upgraded according to the strategies listed in Table 1. Table 2 shows the upgrade status of the 10 test miles. CSX personnel performed the marking of all CSX conventional upgrade miles. ZETA-TECH representatives marked the GRMS and *TieInspect*™ upgrade miles. The CSX large tie force upgraded all test miles in the Cumberland Subdivision last spring. The upgrades in the Metropolitan Subdivision are currently in progress and will soon be completed.

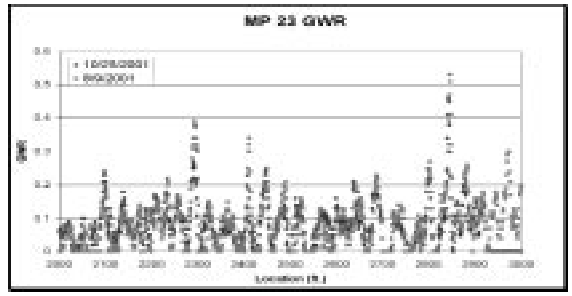

Figure 1. Two Consistent GWR Runs.

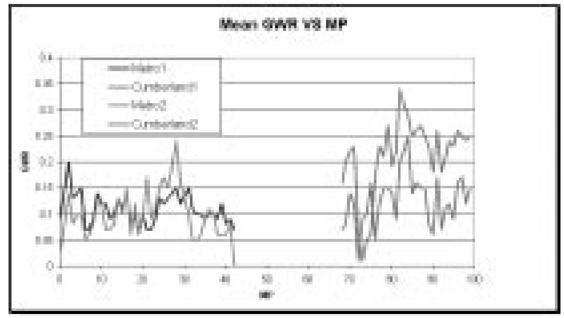

Figure 2. Mean GWR for Two Runs Over Both Subdivisions.

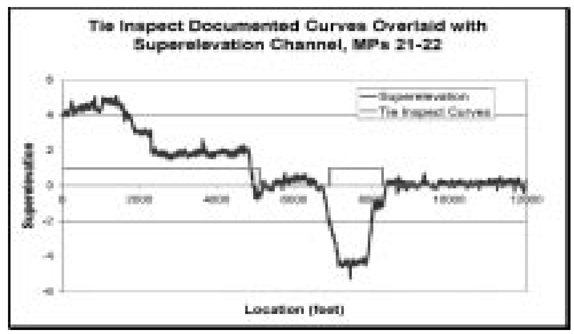

Figure 3. *TieInspect™* Documented Curves Overlaid with Superelevation Channel.

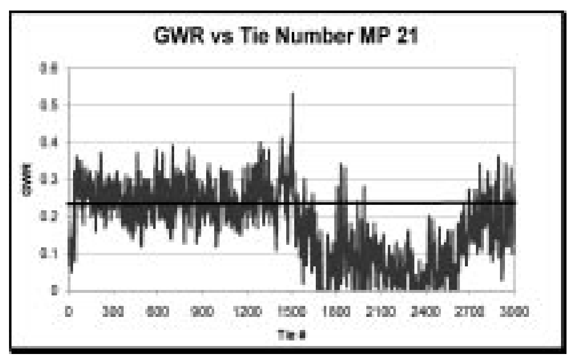

Figure 4. GWR Versus Tie Number

What Lies Ahead?

It is anticipated that a small tie gang will soon complete the upgrades of the Metropolitan Subdivision. Upon upgrade completion, Task 5 (Ongoing Monitoring of Track Condition) and Task 6 (Analysis of Track Condition) will commence. These tasks involve collecting new GRMS data at each run and performing "spot" maintenance in accordance with assigned maintenance methodologies. After several years of monitoring, Task 7 (The Life Cycle Costing Analysis) will combine tie degradation and condition data, with the number of ties installed at each site. This analysis will provide an indication as to the optimal methodologies to upgrade and maintain ties based on degradation and cost effectiveness. Project completion is scheduled for September 2004. §