Crossties

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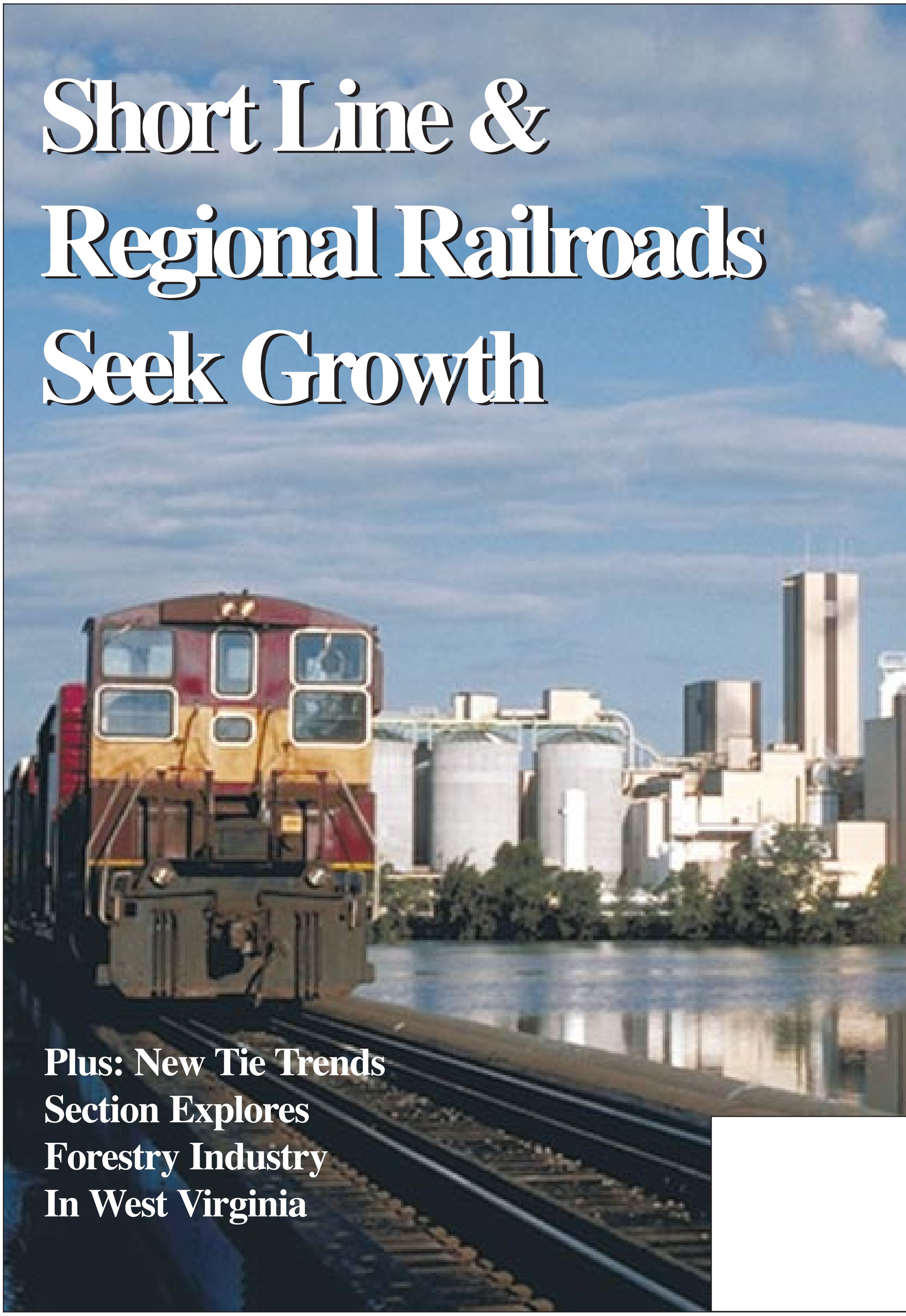
SPECIAL FOCUS ON SHORT LINE & REGIONAL RAILROADS
SEE PAGE 10



Short Line & Regional Railroads Seek Growth

Plus: New Tie Trends Section Explores Forestry Industry In West Virginia

Special Reports

Report On Short Line, Regional Railroads Focuses On 2 Dynamic Roads

New ASLRRA President Profiled In Q&A Interview

TRB Presentation Covers Engineered Hybrid Wood Tie

Registration Form For 1999 Tie Grading Seminar Inside

Executive Committee Establishes Fiscally Responsible, Sound Plan For 1999

AAR's O'Bannon Discusses Threat Of Reregulation

Determination Of Future Crosstie Requirements From Gage Strength Measurements

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As part of its Next Generation High Speed Rail Program, a Federal Railroad Administration (FRA) sponsored project looked at the development of "maintenance" criteria and associated crosstie replacement requirements for both conventional and high-speed railroad track based on the use of the new generation track (gage) strength measurement systems.

These systems, which measure the lateral deformation (and associated strength) of the tie/fastener systems in track, are currently being used by a number of railroads to measure the track strength from a safety point of view, i.e., to locate weak spots in the track, particularly clusters of poor or inadequate ties.

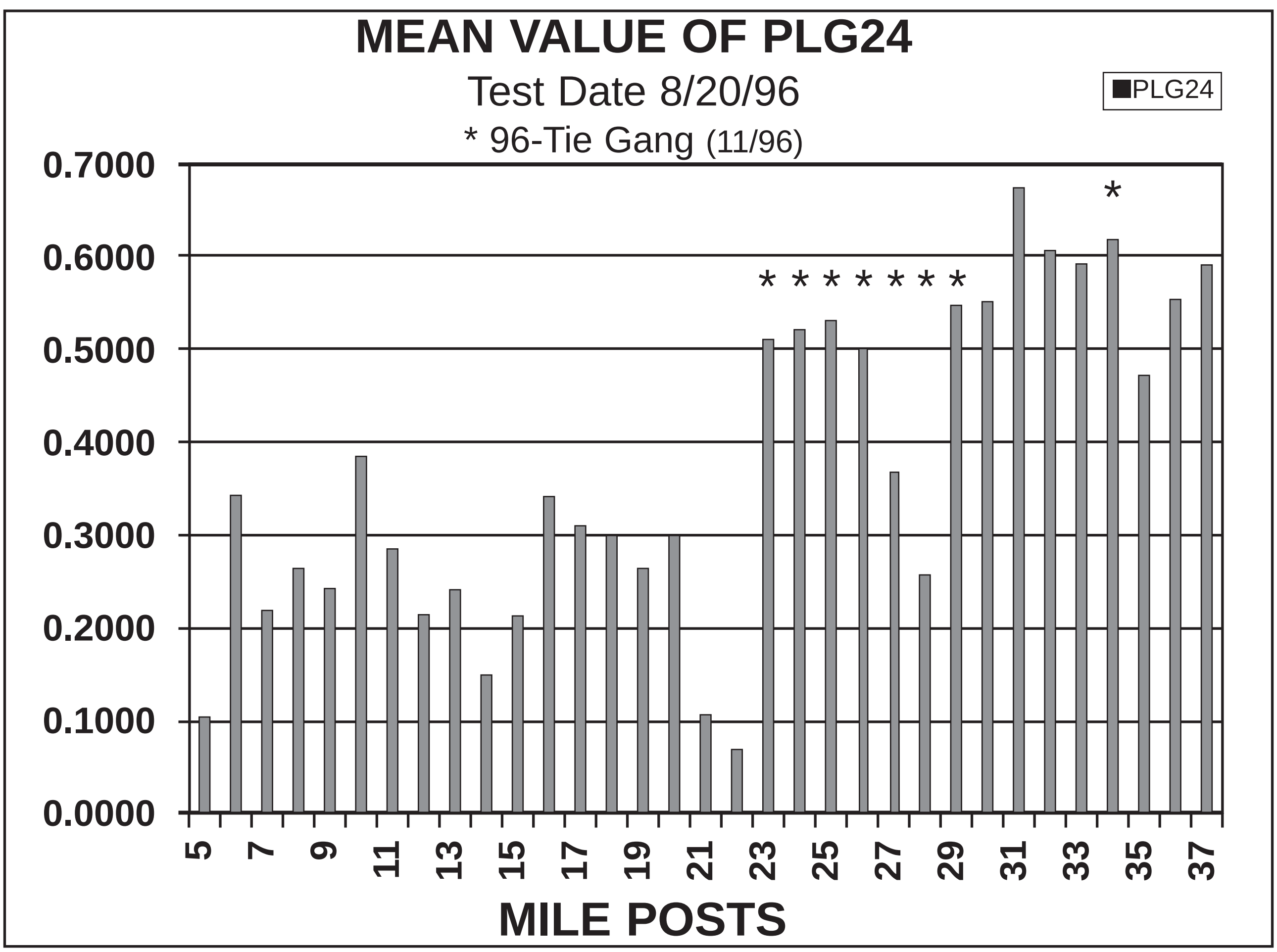
The focus of this FRA-sponsored project, for which the RTA served as a technical advisor, was on the development of maintenance parameters for ties and fasteners and corresponding tie replacement requirements based on objective track (gage) strength measurements. Such a maintenance approach would allow for more cost-effective maintenance for both conventional and high-speed track. The project made use of track strength data taken by CSX Transportation's GRMS track inspection vehicle. The study examined the CSX Transportation line segment between Richmond, Va., and Washington, D.C. Track 3, between MP 4 and MP 109, was selected for analysis because of data availability and history of recent tie installations. This line segment sees regularly scheduled GRMS vehicle tests and supports a mix of freight traffic to include coal, intermodal and mixed traffics. The line segment is also a potential site for increased speed passenger operations.

The results of the study showed that Track Strength Quality Indices (TSQI), similar in behavior to the commonly used track geometry Track Quality Indices (TQI) can be developed. These TSQIs relate the GRMS output data to the general condition of the tie-fastener system and can be correlated to the number of ties installed to develop a predictive relationship between improvements in TSQIs and ties installed.

The TSQI parameters that were found to be most meaningful in representing the track condition were mean values, calculated over a mile length of track, of the following key GRMS outputs: Loaded Gage; Projected Loaded Gage (PLG 24)[1]; Delta Gage (Loaded Gage-Unloaded Gage)[2] ; and Gage Widening Ratio (GWR)[2,3].

In addition, meaningful correlations were

FIGURE 1



also obtained by summing the number of feet per mile (or number of ties per mile which was calculated by dividing length by tie spacing) exceeding a defined PLG24 or GWR threshold.

Analysis of the CSX tie insertion data shows a good correlation between mean PLG 24 (specifically mean PLG24>0.5[4]) and mean GWR (GWR>0.30) and actual tie insertions performed by a production tie gang. This is illustrated in Figure 1. Furthermore, analysis of the number of feet of track, per mile, exceeding these thresholds, likewise shows a correlation with the tie insertions, though the variation in this parameter is significantly greater than for the mean value shown in Figure 1. This correlation supports the use of GRMS data as a maintenance management tool.

Analysis of the GRMS degradation data (between the 1996 and 1998 GRMS runs), as presented in Figures 2 and 3, showed that in those zones where no ties were inserted (4 zones), the mean loaded gage and the PLG 24 increased in all cases, corresponding to a degradation of tie condition with time and traffic. Furthermore, the zone with the greatest traffic density, MP 4 through 22, had the largest increase in mean loaded gage, an increase of 80 percent for mean loaded gage. Overall, for all zones, the loaded gage increased by 37 percent, from 0.19 to 0.26. Based on an average tonnage of 65 MGT over the two years, this corresponds to an increase in loaded gage of 0.0011 per MGT. The corresponding degradation relationship for PLG24 is given by: PLG24 new = PLG24 old + 0.001*MGT

Analysis of the GRMS data for the zones where ties were inserted showed that in these cases, the average loaded gage and associated PLG24 decreased, corresponding to the improvement in track strength due to the new ties and fasteners. Using statistical regression techniques, this data resulted in the development of a correlation between the Track Strength Quality Index parameters and the number of ties inserted, as illustrated in Figure 4.

The resulting relationship for the improvement in PLG24 as a function of the number of inserted ties is given by: PLG24 (new) = PLG24 (old) +A'*TIES+b',

where:

- PLG24 (new) is the predicted mean (per mile PLG24 after ties are inserted);
- PLG24 (old) is the measured mean (per mile PLG24 prior to ties inserted);
- TIES is the number of ties inserted in the mile;
- A' is a constant (slope) equal to -0.0002;
- b' is a constant (intercept) equal to 0.025 (for insertions greater than 35 ties per mile); and
- A similar relationship was obtained for Loaded Gage.

Based on the results of the measurements and data collected on this line, together with earlier FRA and TSC test data for track strength values, a set of maintenance thresholds for the TSQI planning index were developed. These per-mile mean limits for PLG24 (the "maintenance" PLG24) were set as is shown in the box at right:

	"Maintenance" PLG24	
Low Speed Freight (Class 3)	0.625	57 1/8"
Moderate/High Speed Freight Track (Class 4)	0.5	57"
Passenger (Class 6)	0.375	56 7/8"

Note: the limit of 0.5 (57") corresponds to the measured average of the mean PLG24 on the track that was actually timbered by CSX (thus determined by the railroad inspectors as requiring ties).

These limits allow for the determination of the number of ties to be inserted per mile by calculating the difference between the "actual" (measured) mean PLG24 for the mile and the above-defined limit. This difference is then divided by the "slope" of the PLG24 equation presented previously to calculate the number of ties to be inserted.

Application of these limits to the study track showed that for current operations (Moderate Class 4 track), the above defined mean PLG24 limits can be reached with between 50 percent and 80 percent of the actual ties installed (based on obtaining an

Figure 2

equivalent mean average PLG24 comparable to what was actually achieved, which was of the order of 0.47). For high speed track, with the more restrictive PLG24 limit noted above (.375" corresponding to 56 7/8"), the above-defined equation can be used to determine the number of ties necessary to bring the track to the higher strength standard associated with high speed operations. The results of such an analysis is presented in Table 1 which shows, for several specific mileposts, the number of ties that would have to be installed to reach the more restrictive PLG24 level required for high speed track.

Figure 3

Figure 4

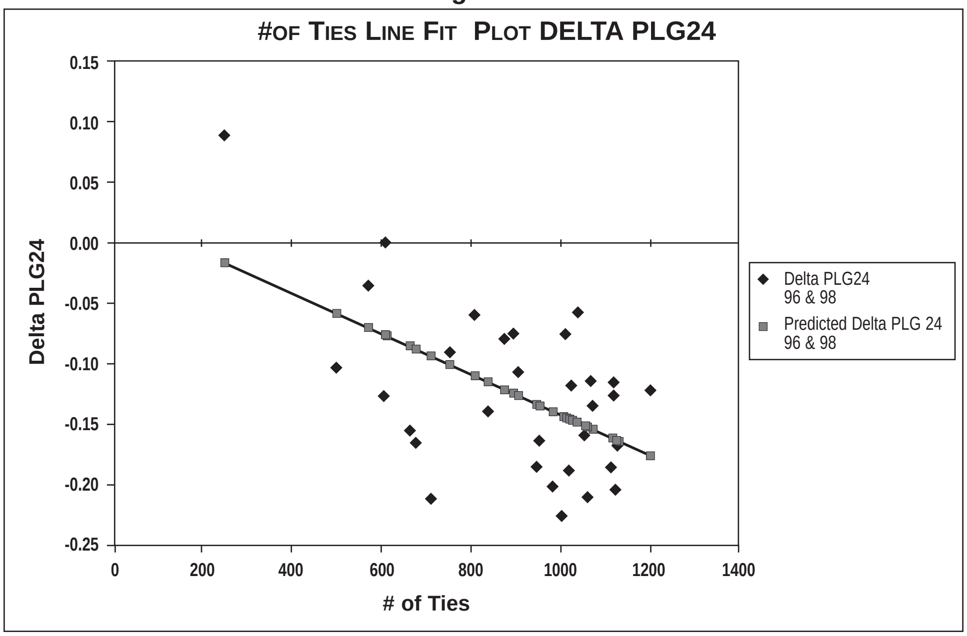


Table 1
Example Tie Insertion Analysis

Milepost	Mean PLG24 8/96	Mean PLG24 5/98	Actual Ties Inserted 11/96	Ties Required for PLG24 0.47[6]	Ties Required for PLG24 0.375
23	0.51	0.41	500	233	802
29	0.54	0.33	711	431	1000
34	0.61	0.41	1124	862	1431

The study concludes that, based on the presented results, it appears that the GRMS data, when developed in the form of TSQI values, on a mile by mile or segment by segment basis, can be used as part of the maintenance planning process as well as a predictor of crosstie replacement requirements. The next step in the process is the demonstration of whether such a track strength based approach to tie replacement provides a more economical means, on a life cycle basis, to upgrade and maintain track for mixed heavy freight and high-speed passenger operations.

Acknowledgement

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Footnotes:

1PLG24=UTG+A*(LTG-UTG) *where*
- UTG is the unloaded gage;
- LTG is the loaded gage
- A is a constant of the order of 1.6 for the GRMS vehicle

2Note: only limited results were obtained from this parameter due to an apparent data problem with the unloaded gage measurements taken from the August 1996 GRMS run.

3Gage Widening Ratio GWR = (LTG-UTG)/L * 16000 *where*
- UTG is the unloaded gage
- LTG is the loaded gage
- L is the lateral load applied by the GRMS.

4As used here, the PLG24 value represents the value above nominal gage of 56 1/2". Thus a PLG24 value of 0.5 would correspond to a value of 57".