TECHNOLOGY DIGEST
Timely Technology Transfer

LATERAL TRACK STRENGTH TESTING ON NORFOLK SOUTHERN RAILROAD

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Summary

For the first time, the Track Loading Vehicle (TLV) has been used to measure the effects of maintenance operations on lateral track strength in revenue service. This digest reviews TLV testing on the Norfolk Southern (NS) railroad during June 1997. The TLV was used to measure track strength in conjunction with a tie-replacement and surfacing operation.

Although this operation does not normally include a dynamic track stabilizer, NS added this in certain test zones. The NS tests expanded the database obtained from tests conducted at the Transportation Technology Center (TTC) near Pueblo, Colorado.

The TLV study was jointly funded by the Association of American Railroads and the Federal Railroad Administration.

Conclusions drawn from the tests include:

- The tie-replacement (20 to 25 percent) and ballast-tamping process led to a lateral strength reduction of almost 50 percent. This magnitude agrees with the significant strength reduction due to ballast tamping or ballast installation which was observed during previous TTC tests.
- Following tamping, 0.1 million gross tons (MGT) of traffic recovered roughly 30 percent of the lost track strength (to roughly 65 percent of the original strength). This rate of traffic-induced strength recovery is consistent with the previous TTC tests on a similar track structure.
- Use of a dynamic track stabilizer following tie replacement and ballast tamping improved track strength equivalent to the effect of roughly 0.1 MGT. This was less than the effect of similar stabilizer tests conducted on TTC track, which included skin-lift tamping, but no tie changes.
- TLV tests on 5- to 9-degree curves did not exhibit lower track strength than on tangents under the post-maintenance ballast conditions: newly tamped, DTS-stabilized, and up to 0.1 MGT traffic.

Suggested Distribution:
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☐ Planning and Analysis
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INTRODUCTION AND CONCLUSIONS

"Lateral Track Strength/Panel Shift Tests" is a project jointly funded by the Association of American Railroads (AAR) and the Federal Railroad Administration. Objectives of the project include developing performance-based guidelines to optimize train slow orders used immediately after track maintenance, and improving maintenance techniques while ensuring adequate track strength. To achieve these objectives, the AAR's Track Loading Vehicle (TLV) has been used to examine lateral strength parameters as influenced by various track conditions and maintenance operations.

Extensive tests were conducted on the test tracks of the Transportation Technology Center (TTC) during 1996 and the first quarter of 1997. The main findings have been reported in previously published Technical Digests (TD 97-04, -05, -06 and -25). AAR expanded this database to include revenue-service conditions through track strength tests in June 1997. Norfolk Southern (NS) Corporation hosted this test series, in conjunction with regular NS track maintenance operations.

TLV tests were conducted on NS tracks immediately before and after tie replacement (20 to 25 percent) and ballast tamping, as well as immediately following ballast consolidation via traffic and via a dynamic track stabilizer (DTS) and led to the following conclusions:

- Tie replacement and ballast tamping led to a strength reduction of approximately 50 percent. This agrees with the significant strength reduction due to ballast tamping or ballast installation which was observed from previous TTC tests.[1]
- Following tamping, 0.1 million gross tons (MGT) of traffic recovered roughly 30 percent of the track strength loss (to roughly 65 percent of the original strength). This rate of traffic-induced strength recovery is considered consistent with the previous TTC tests on a similar track structure, which showed that more than 0.5 MGT was required to restore most of the lost strength.[1]
- DTS use following tie replacement and ballast tamping improved track strength equivalent to the effect of roughly 0.1 MGT. This was less than the effect of a similar stabilizer equivalent to roughly 0.3 MGT as found in tests conducted at TTC.[1] However, the TTC tests included skin-lift tamping, but no tie changes.
- TLV tests on 5- to 9-degree curves did not exhibit lower track strength than on tangents under the post-maintenance ballast conditions: newly tamped, DTS-stabilized, and up to 0.1 MGT traffic.

TRACK MAINTENANCE AND TLV TESTS

During the period of June 9–12, 1997, stationary TLV tests were conducted on Class 4 NS mainline tracks near Oakvale, Virginia. Tests were scheduled in conjunction with the NS crosstie-replacement and ballast-tamping operations. Of existing crossties, 20 to 25 percent (higher percentage for the curves but lower for the tangents) were being replaced with new hardwood crossties. Exhibit 1 shows the TLV on the NS revenue track with new crossties ready at wayside.

TLV track strength tests were performed between Mile Posts N345 and N350. This track consists of 136-pound, continuous-welded rails, granite ballast, wood ties with cut spikes (two spikes per plate on the tangent versus five per plate on the curve), both before and after the maintenance. A pair of rail anchors are used for every other tie on the tangent, and for every tie on the curve. The nominal ballast shoulder width is 6 inches for the tangent and 12 inches for the curve, respectively. Tests were conducted immediately before and following tie replacement and ballast tamping (June 9 and 10, respectively). Although its use was not part of the scheduled maintenance operations, a dynamic track stabilizer (Plasser PTS-62) was applied immediately following tamping in several track zones for TLV strength tests on June 11. The DTS was operated by NS personnel and examined by Plasser personnel immediately prior to the test. In addition, TLV tests were conducted at post-gang traffic accumulations of 0.04 and 0.1 MGT (June 11 and 12, respectively).

TLV tests were conducted on both tangent and

Exhibit 1. TLV Track-Strength Testing in Conjunction with Track Maintenance in Norfolk Southern Track

curved (5- to 9-degree) tracks, for four tie-ballast interface conditions: consolidated (prior to tie replacement), weakened due to tamping, stabilized, and traffic-consolidated. At curves, the lateral TLV load was always applied toward the outside direction. For each tie-ballast condition, a total of 15 to 25 stationary tests were completed. The minimum distance between two adjacent test locations was 50 feet. During a stationary test, the TLV load bogie maintained a constant vertical axle load of 20,000 pounds on the track, and applied an increasing lateral load to push the track panel relative to the ballast. The track panel displacement was measured as tie deflection relative to the ballast using transducers placed at three consecutive tie ends nearest the load axle.

For most TLV tests, the track panel was pushed to 0.3 inch maximum deflection. TLV stationary strength values are defined as the lateral axle load necessary to achieve certain magnitudes of lateral track deflection such as $L_{0.05}$ (0.05 inch deflection) and $L_{0.1}$ (0.1 inch deflection). To account for measured strength variations at different test locations, mean and standard deviation values have also been analyzed.

TEST RESULTS AND ANALYSIS

Test results were first compared between tangent and curved tracks. Exhibit 2 shows mean strength ($L_{0.1}$) values obtained for both the tangents and curves at three post-tamping tie-ballast conditions: newly tamped, DTS-stabilized, and 0.1 MGT following tamping. As shown, no obviously higher strength can be seen for tangents than for curves at these three tie-ballast conditions. This may seem counter-intuitive, but TLV stationary track strength primarily depends on the tie-ballast interface. Rail-bending stiffness and rail/tie-fastener rotational stiffness also contribute to track panel strength. In a curve, lower panel-bending stiffness is often compensated for by higher rotational fastener stiffness (due to more fasteners in the curve). As to longitudinal rail forces, their effects on panel shift during a TLV test are not considered to be significantly larger on curves than at tangents. It is conjectured that due to the restraints from four vertical axle loads (roughly 60 kips each) under two TLV trucks and the 20-kip test bogie vertical load, rail longitudinal forces will not generate significant lateral panel deflection, regardless of curvature. Therefore, further test results were grouped only in terms of tie-ballast conditions, not curvature.

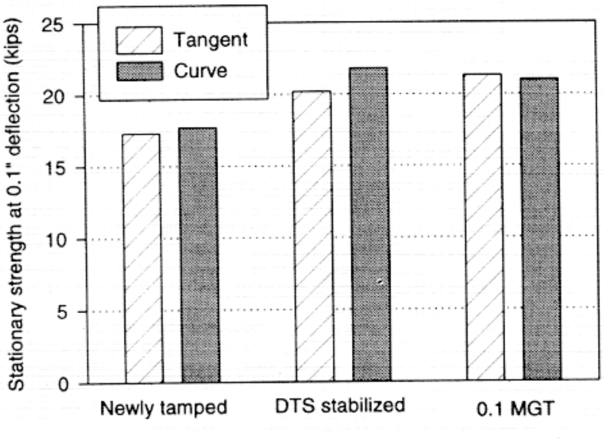

Exhibit 2. Comparison of Mean Test Results for Tangent and Curve (5- to 9-degree) Tracks following Tamping and Consolidation

Exhibit 3 shows load-deflection relationships for four tie-ballast conditions: baseline prior to tie replacement (consolidated), newly tamped, following 0.1 MGT, and DTS-stabilized following tamping. The solid lines are the mean values of all the tests conducted for each condition. The data variations are reflected using bands of plus and minus one standard deviation, and are shown by shading.

Under the three conditions following tamping, track panels were pushed up to 0.3 inches. However, prior to tie replacement, the preset TLV maximum lat-

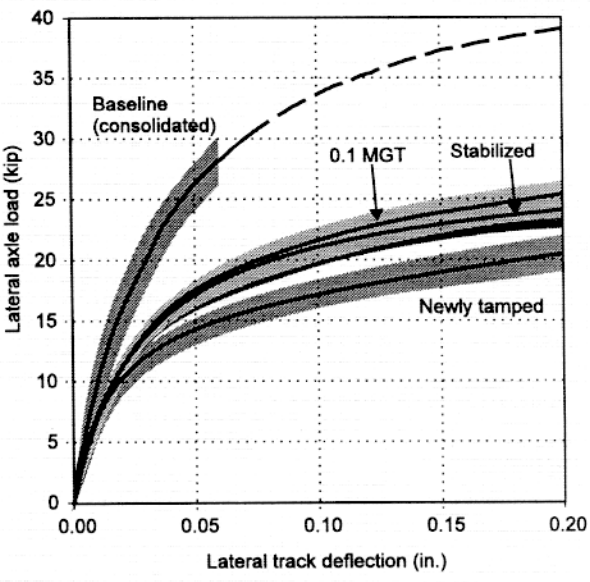

Exhibit 3. Comparison of TLV Test Results for Consolidated, Newly Tamped, following 0.1 MGT, and DTS Stabilized (Line is Mean Data, Shading is ±1 Standard Deviation)

eral load of 30,000 pounds did not push the panel this far. (The force limit was a precaution by the AAR test crew to prevent possible excessive shifting of the revenue track.) Extrapolation of the baseline test results above 30,000 pounds for the condition before tie replacement is shown by a dashed line in Exhibit 3. This extrapolation uses a validated lateral load-deflection equation[2] $\{L=a\delta + \delta/(b+c\delta)$, where L = load, δ = deflection, a, b, c = fit coefficients$\}$ to estimate results up to 0.3 inch. The different strength characteristics (as measured by TLV) due to the four test conditions are quite obvious, as Exhibit 3 shows.

A quantitative comparison of various track strengths is presented in Exhibit 4, which shows the $L_{0.05}$ and $L_{0.1}$ strength parameters. As shown, the tie replacement and tamping caused a strength loss of almost 50 percent. Traffic following tamping gradually recovered the lost strength. Of the loss due to tamping, roughly 30 percent was restored (or 65 percent of the original strength was achieved) via 0.1 MGT of traffic. Similarly the DTS application following tamping recovered roughly 65 percent of the original baseline strength, indicating that the DTS is equivalent to the effect of 0.1 MGT of traffic.

Results shown in Exhibit 4 are consistent with what was found from tests conducted on a similar TTC track.[1] Previous TTC tests showed that ballast tamping or reinstallation led to a large track-strength loss, and most of this loss was recovered via 0.5 MGT of traffic. However, use of a dynamic track stabilizer was found to be more effective on the TTC track than at NS, recovering a portion of the lost strength equivalent to the effect of roughly 0.3 MGT. Several factors may account for this difference in DTS performance, such as variation in DTS operations and in slow-order policies, skin-lift tamping on the TTC test, etc. Also, on the revenue track 20 to 25 percent of the existing crossties were replaced, and it is postulated that a DTS may be more effective with used ties having rougher surfaces.

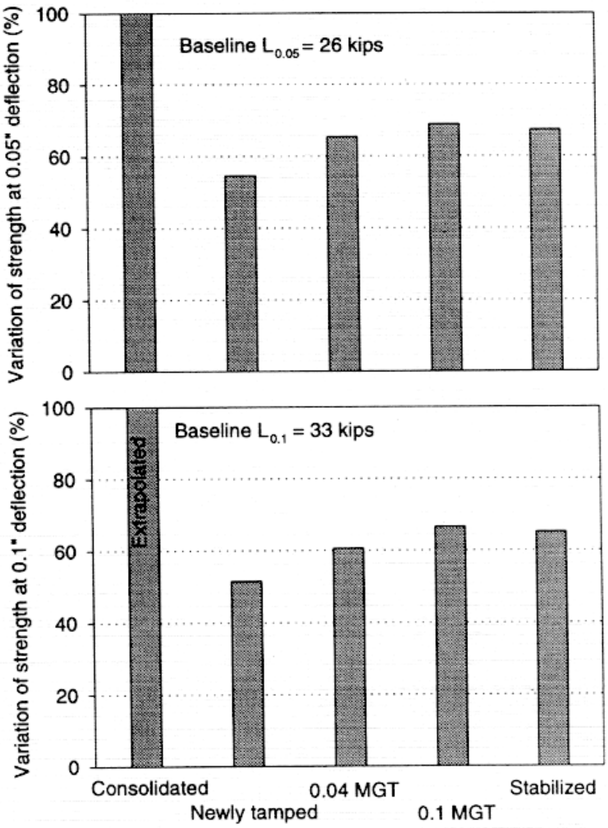

Exhibit 4. Lateral Track Strength before and after Various Maintenance and Traffic

ACKNOWLEGMENTS

AAR/TTC would like to express appreciation to Norfolk Southern for hosting these tests, and to Plasser American for supporting the dynamic track stabilizer operation. We also thank the Federal Railroad Administration for its continuing partnership in this project.

REFERENCES

1. Li, D., Cooke, J. and Shust, W., "Preliminary assessment of the effects of track maintenance on lateral strength," Technical Digest 97-25, Association of American Railroads, July 1997.
2. Leshchinsky, D., "Development of predictive equation for lateral track behavior," R-481, Association of American Railroads, June 1981.

Note: Contact Dingqing Li at (719) 584-0740 with questions or comments about this document.
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