TECHNOLOGY DIGEST
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Cross-tie renewal: New Tie Cluster Size vs. Lateral Track Strength

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Summary

Tests conducted by Transportation Technology Center, Inc. (TTCI), in cooperation with the Norfolk Southern (NS) Corporation, indicated that increasing the number of new ties (3 to 9) in a cluster during cross-tie renewal lengthened the zone temporarily weakened by the maintenance operation, but did not lead to further decrease in lateral track strength.

Moreover, among the four cluster sizes (3, 5, 7, and 9), no significant difference was observed concerning track-strength recovery due to use of a dynamic ballast stabilizer. Regardless of cluster size, dynamic stabilization consistently increased lateral track strength from 45 percent to 55 percent of the fully consolidated strength.

TTCI's Track Loading Vehicle (TLV) was used to quantify differences due to the number of ties in a cluster. The test was conducted in May of 1999 on a section of NS revenue track near Abingdon, Virginia. Measurements were obtained continuously along the track and at the center of each cluster using the newly developed TLV in-motion lateral track strength test capability and TLV stationary test technique. Lateral track strength was measured under three track conditions: (1) consolidated, (2) newly tamped and surfaced with various new tie clusters, and (3) stabilized.

The Association of American Railroads funded this study.

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Suggested Distribution:
- ☐ Track Maintenance
- ☐ Maintenance of Way
- ☐ Planning & Analysis
- ☐ Safety

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INTRODUCTION AND CONCLUSIONS

It is well known within the railway industry that the process of tie renewal, ballast tamping, and surfacing can temporarily reduce lateral track strength. Concerned with this loss in track strength and possible rail buckle, some railroads have limited the number of consecutive new ties in a cluster during tie replacements to as few as two. To examine the actual effect of the number of continuous ties changed out in a cluster, the Transportation Technology Center, Inc. (TTCI), in cooperation with the Norfolk Southern (NS) Corporation, conducted a field test in a section of NS revenue track near Abingdon, Virginia, in May of 1999. The new-tie clusters varied from 3, 5, 7, to 9 consecutive ties.

TTCI's Track Loading Vehicle (TLV) was used during this test. Lateral track strength was measured under three track conditions: (1) consolidated, (2) newly tamped and surfaced with various new tie clusters, and (3) stabilized. Measurements were obtained continuously along the track and at the center of each cluster using the newly developed TLV in-motion test capability and the TLV stationary test technique.

The test results indicate that increasing the number of new ties (3 to 9) in a cluster during cross-tie renewal lengthened the zone temporarily weakened by the maintenance operation, but did not lead to further decrease in lateral track strength.

Moreover, among the four cluster sizes (3, 5, 7, and 9), no significant difference was observed concerning track-strength recovery due to use of a dynamic ballast stabilizer. Regardless of cluster size, dynamic stabilization consistently increased lateral track strength from 45 percent to 55 percent of the fully consolidated strength.

TEST ZONES AND TEST METHODS

The test was conducted in a section of NS mainline track between Mileposts NB393 and NB394 near Abingdon, Virginia. Exhibit 1 shows the TLV test train. The tangent track contains continuously welded 132-pound rails, wood ties, and granite ballast. Two spikes hold each tie plate. Rail anchors box every other tie. Before track work was completed, the ballast shoulder was between 17 and 23 inches wide. Following the track work, it is about 6 inches wide.


Exhibit 1. TLV Tie Cluster Test Consist on NS Track

The track was scheduled for timber (tie replacement) and surfacing (T&S) maintenance. The last T&S operation occurred in November 1991. In conjunction with this T&S operation, three track conditions were subjected to TLV testing as follows:

Condition 1: consolidated track (prior to the T&S operation). Five TLV stationary tests and one TLV in-motion profile test were conducted to establish the benchmark track-strength values.

Condition 2: immediately following the T&S operation. Three repeated zones were set up. Each zone included five new tie clusters (0, 3, 5, 7, and 9). Between each adjacent clusters, 10 original old ties were kept in track. For each zone, five stationary tests were conducted at centers of the five tie clusters. Therefore, a total of 15 stationary tests were performed for the three repeated zones under condition 2. Following the stationary tests, one TLV in-motion test was then conducted throughout the entire test track.

Condition 3: immediately following use of a dynamic ballast stabilizer. Upon completion of the tests under condition 2, the three repeated test zones were stabilized using a NS stabilizer. Then, 15 stationary tests and one in-motion test were performed in a similar manner to the ones described under condition 2.

The TLV stationary test was used to determine the relationship between a lateral load (from a single axle) and lateral track deflection. Lateral axle load was increased under a constant vertical axle load of 20 kips, until a maximum lateral tie deflection of 0.3 inch was reached. The required lateral load for a given lateral deflection (e.g., 0.1 inch) is referred to as TLV stationary strength. The TLV in-motion test produces a deflection profile along the track under constant lateral and vertical axle loads (16 and 20 kips, respectively). Higher deflections indicate lower track strength, and vice versa. For more detailed information regarding the TLV lateral track panel strength test techniques, refer to AAR report R-918.

To better interpret TLV in-motion test results, automated location detectors were placed at the center of each tie cluster and were used to locate the test zones.

TEST RESULTS AND ANALYSIS

Exhibits 2 to 4 summarize TLV stationary and in-motion test results concerning the effect of tie cluster size on lateral track strength.

A total of 35 TLV stationary tests were performed for the three track conditions, as shown in Exhibit 2. Tests No. 1-5 were for the consolidated track, tests No. 6-20 for the track following the T&S operation, and tests No. 21-35 for the track following the use of the stabilizer. Exhibit 2 are the TLV stationary strengths at 0.05 and 0.1 inch.

The average strength values (at 0.1 inch) over the three repeated zones are given in Exhibit 3 (left side) for each tie cluster. In this exhibit, three types of bars represent three track conditions (consolidated, T&S operated, and stabilized). In addition, the average test results from three previous NS tests are included in Exhibit 3 (right side).

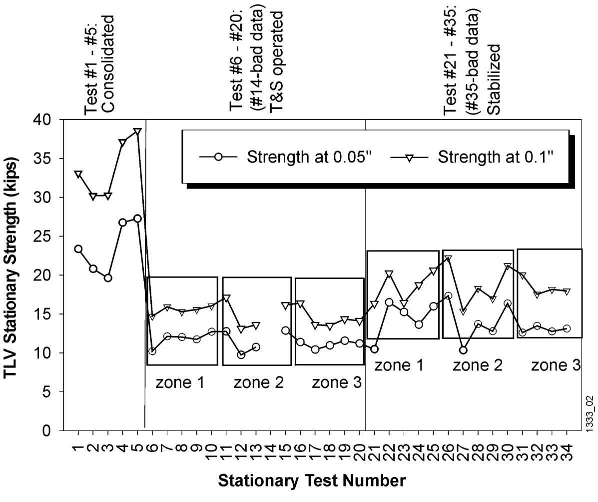

Exhibit 2. Summary of Stationary Track Strength Results (Zones 1 to 3: three repeated sets each including new tie clusters in the order of 0, 3, 5, 7, and 9)

The TLV in-motion test results for track conditions 2 and 3 are given in Exhibit 4. Although the test results for all three zones (under each condition) were obtained from the same test run, the results are shown in three separate plots (a, b, c) each corresponding to one zone. Note that the vertical dotted lines indicate the centers of the tie clusters.

The following is the analysis based on the results shown in Exhibits 2 to 4.

Effect of tie clusters

As mentioned earlier, tie clusters in the order of 0 (no new ties), 3, 5, 7, and 9 were included in each of the three repeated zones. In terms of TLV stationary strengths (Exhibits 2 and 3), as well as peak deflections generated during the in-motion tests (Exhibit 4), no significant effect can be assessed due to variation in tie clusters from 3, 5, 7, to 9. In other words, the measured TLV stationary strengths and peak deflections did not exhibit a trend as a function of tie-cluster number (from 3 to 9).

However, the track without new ties (cluster size = 0) exhibited higher track strength. This can be seen to be more obvious from the in-motion test results (Exhibit 4). As shown, the generated

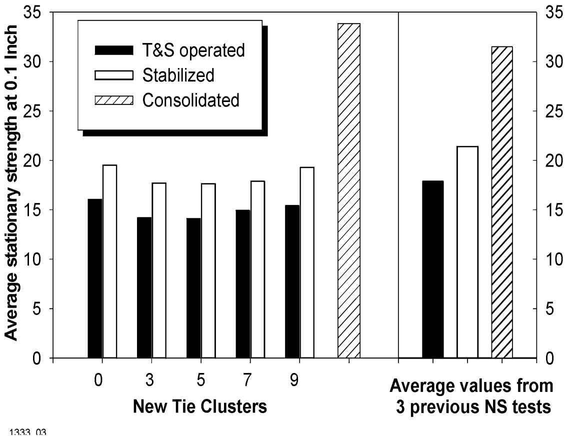

Exhibit 3. Average Stationary Strengths at 0.1 Inch

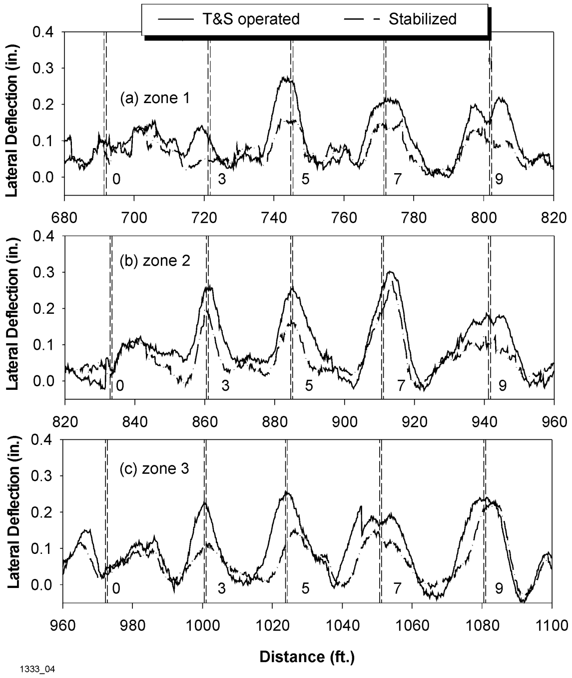

Exhibit 4. TLV In-motion Test Results

deflections for the track without a new tie were consistently lower than the deflections for the track with new-tie clusters.

The resulting larger difference due to existence of new ties than due to variation in tie clusters (3, 5, 7, 9) can also be seen in TLV stationary tests (Exhibit 3), though it is not as obvious. As shown, except for the last cluster (9), the track without a new tie had slightly higher strengths than the track with new-tie clusters.

As shown in Exhibit 4, increase in tie cluster size from 3 to 9 did increase the affected deflection basin length. In other words, the weakened zone length due to new tie installation increased as the number of ties in a cluster increased.

Effect of dynamic ballast stabilization

The effects of T&S operation and dynamic ballast stabilization on track strength are also shown in Exhibits 2 to 4. In Exhibit 3, the average results from three previous tests are included for comparison. In this test, as an average, track T&S operation caused a stationary strength reduction to 45 percent of the consolidated strength. Use of a NS stabilizer recovered strength to 55 percent. From the average of the three earlier tests, ballast tamping and surfacing operations caused a strength reduction to 57 percent, and use of a stabilizer returned the strength to 69 percent. Note that the larger decrease in track strength due to T&S operation in this test might be caused by larger reduction in ballast shoulder width during this maintenance operation, as mentioned earlier.

The effect of dynamic ballast stabilization can also be seen from the TLV in-motion test results. As shown in Exhibit 4, the measured deflection magnitudes were lower for the stabilized track than the track immediately following the T&S operation. As an average, the peak deflection decreased from 0.19 inch to 0.13 inch as a result of dynamic ballast stabilization.

ACKNOWLEDGMENTS

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A MORE DETAILED REPORT, WHICH MAY CONTAIN REVISED INFORMATION, MAY BE AVAILABLE AT A LATER DATE THROUGH AAR/TTCI, PUBLICATIONS, P.O. Box 79780, BALTIMORE, MD, 21279-0780.