

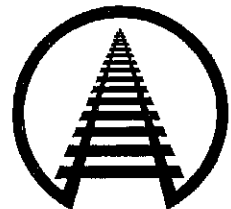
PRELIMINARY ASSESSMENT OF THE EFFECTS OF TRACK MAINTENANCE ON LATERAL STRENGTH

by Dingqing Li, Joy Cooke and
William C. Shust
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More railroads are beginning to use dynamic track stabilizers for ballast consolidation to minimize speed restrictions and return train operation to track speed quickly and efficiently. Data collected between January and March 1997 at the Facility for Accelerated Service Testing (FAST), Transportation Technology Center (TTC), Pueblo, Colorado, has been examined by TTC engineers to determine the effect a dynamic track stabilizer has following ballast tamping. Panel strengths with different tie types at newly tamped ballast conditions also were examined. The study is a cooperative effort between the AAR and the Federal Railroad Administration.

Data from these tests show:

- Track lateral strength is reduced significantly by ballast tamping operations even if the rail lift is relatively small (0.5 to 1 inch).
- The traffic induced strength recovery following tamping depends upon ballast type and its characteristics. Tests on TTC's granite ballasted track showed that most of the strength loss was restored within 0.5 million gross tons (MGT). However, previous tests on a different type of ballast showed that approximately 4 MGT was required for a similar degree of strength recovery.
- Dynamic track stabilizers can significantly accelerate ballast consolidation and strength recovery on wood-tie track. Preliminary results on wood-tie track with granite ballast indicate that use of a dynamic stabilizer following tamping may produce ballast consolidation resulting in a strength recovery approximately equivalent to the effect of 0.3 MGT of heavy axle load traffic.
- Various crosstie types affect initial track lateral strength more than they affect consolidated track strength. With newly installed ballast, both concrete and steel ties showed significantly greater initial strength than wood ties. However, this difference is lessened as the ballast consolidates.



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INTRODUCTION AND CONCLUSIONS

Adequate lateral track strength is essential to railroad track stability under high-lateral wheel/rail forces and/or high-longitudinal rail compressive forces. As part of the Association of American Railroads' (AAR) Track Strength Test Program, engineers have conducted extensive field tests to quantify track strength loss due to ballast tamping and strength recovery under traffic or machine-induced ballast consolidation.

Lateral track strength discussed here refers to track panel shift strength at the interface of ties and ballast. A major side effect of track maintenance operations, such as surfacing and ballast tamping, is the considerable reduction of lateral track strength due to weakened ballast and tie-ballast interface. Slow-order policies are implemented on train operations immediately following track maintenance to compensate for reduced lateral strength. These slow-order policies disrupt normal train operations and reduce railroad efficiency. To eliminate or reduce the duration of slow orders, track maintenance equipment such as dynamic track stabilizers are often used to accelerate ballast consolidation.

Results from the field tests performed using AAR's Track Loading Vehicle (TLV) on test tracks at the Transportation Technology Center (TTC), Pueblo, Colo., include:

- Track surfacing and ballast tamping, even with only a small amount of rail lift (0.5 to 1 inch), can cause significant reduction in lateral track strength.
- The traffic induced strength recovery following tamping depends upon ballast type and its characteristics. Tests on TTC's granite ballasted track showed that most of the strength loss was restored withing 0.5 million gross tons (MGT). However, previous tests on a different type of ballast showed that approximately 4 MGT was required for a similar degree of strength recovery.
- Track dynamic stabilizers can significantly accelerate ballast consolidation or strength recovery on wood-tie track. Preliminary results on wood-tie track with granite ballast indicate that use of a dynamic stabilizer following tamping may produce ballast consolidation resulting in a strength recovery approximately equivalent to the effect of 0.3 MGT of heavy axle load traffic.
- Loss and restoration of track strength due to tamping and traffic or machine induced consolidation all

depend upon ballast and tie types. For tracks with newly installed ballast, the use of concrete ties and steel ties (inverted trough types) provided much higher initial track strength than wood ties. Once ballast becomes consolidated, however, the difference in lateral track strength due to various ballast and tie types is reduced.

TEST METHODS AND TEST TRACKS

Engineers know that ballast tamping, traffic, and stabilizing machines may all significantly affect ballast consolidation, and therefore lateral track strength. Many studies have been conducted to quantify the effect of ballast consolidation on track strength. Examples of recent studies conducted in Europe and United States can be found in references 1 to 5. However, many questions still remain as to appropriate track strength measurement techniques and the effects of various track parameters on lateral strength. Moreover, full-scale in-motion lateral track strength testing had not been attempted on North American railroad tracks. To meet these needs, the AAR designed and constructed the TLV, which can accurately simulate loaded wheel/rail interactions and measure track responses. Measurement of lateral track panel strength is one of many TLV applications.

TLV tests have been developed for stationary and in-motion lateral track strength measurements.⁶ In stationary tests, the TLV pushed the track laterally using a constant vertical axle load and normal wheel profiles. Lateral track panel deflections were measured as tie deflections relative to the ballast. Lateral track strength and stiffness can be defined based on load-deflection curves and are dependent upon vertical axle load and allowable track panel deflection.⁶

In a single pass in-motion test, constant lateral and vertical axle loads ($L = 16$ kips and $V = 20$ kips in this case) were applied to the track while the TLV traveled at 2 to 5 mph, and lateral track panel deflections were measured within a test zone comprising 12-tie locations (at 6 to 10 tie intervals). The resulting peak deflection magnitudes give indications of lateral track strength. In other words, a strong track will deflect less than a weak track.

NEWLY TAMPED OR INSTALLED BALLASTS WITH DIFFERENT TIES

Exhibit 1 shows the results of lateral track deflections generated during in-motion TLV tests for three ballast



consolidation conditions. The track structure consists of wood ties, cut spikes, and granite ballast on the High Tonnage Loop (HTL). An average maximum deflection of 0.05 inch was measured for the well consolidated ballast. The largest average deflection of roughly 0.19 inch was measured for the newly installed ballast. This variation indicates a significant difference in track strength between the well consolidated and the newly installed ballast. The third ballast condition resulted from ballast tamping with a rail lift of 0.5 to 1 inch. As shown, the loss of track panel strength was also significant, as indicated by a deflection magnitude of 0.15 inch, which was nearly as much as for the newly installed ballast. In other words, the track strength loss due to a "0.5- to 1-inch rail lift" tamping was close to the loss due to complete ballast replacement.

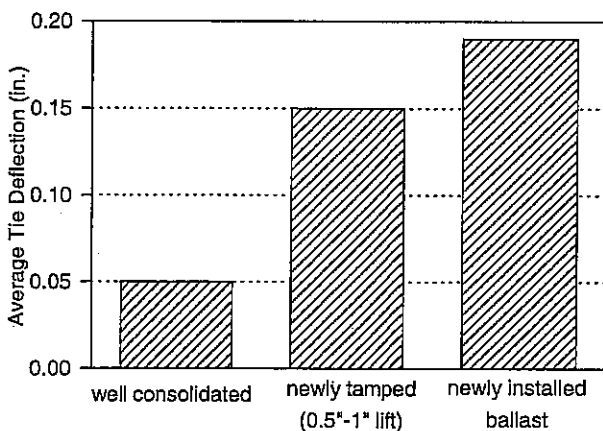


Exhibit 1. Effects of Ballast Tamping on Lateral Track Deflection due to Constant Moving Lateral and Vertical Loads (Wood Ties, Cut Spikes and Granite Ballast)

Using a reference track with well consolidated ballast and wood ties, lateral track strengths for four other cross-tie types are compared in Exhibit 2. These four sections of tracks all had newly installed granite ballast. As shown in this exhibit, the wood-tie section had the largest lateral deflection due to the moving load; i.e., the lowest track strength. Other sections with concrete and steel ties (inverted trough types) showed much lower track deflections; i.e., higher lateral track strength. (Note that we did not conduct TLV tests on T-cross section steel ties, but we plan to soon). In the case of a newly installed ballast, sections with concrete and two steel tie types all showed much higher track strength or lower generated track panel deflections than the wood tie section. The TLV test results shown in Exhibit 2 are also

consistent with companion test results performed using single tie push testing.

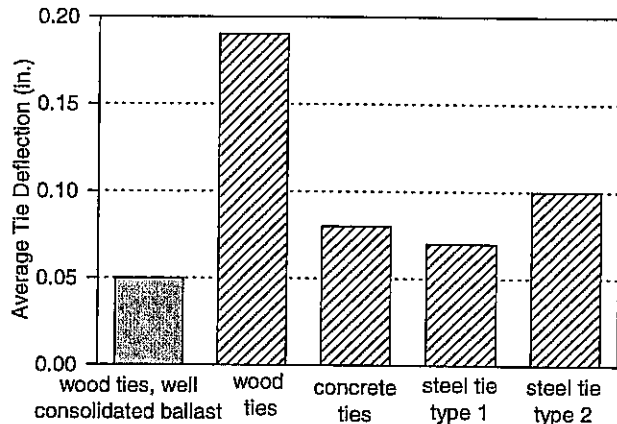


Exhibit 2. Comparison of Lateral Track Deflections due to Constant Moving Lateral and Vertical Loads for Newly Installed Tracks with Various Tie Types

TRAFFIC AND STABILIZER INDUCED-BALLAST CONSOLIDATION

Exhibit 3 shows restoration of track strength induced by train traffic following ballast tamping or installation. It also shows that the newly installed ballast suffered a large strength loss (i.e., a large increase in deflection) relative to the fully consolidated condition. Of that loss, most was recovered with 0.5 MGT of FAST traffic. However, previous TLV tests on a different type of ballast (with a similar track structure) showed that up to 4 MGT was required for a similar degree of strength recovery (up to 9 MGT was required to fully develop the lateral track strength).⁶ In other words, traffic induced strength recovery depends on ballast type and characteristics. One possible explanation is that ballast with different gradation, shape, and unit weight may settle differently and consequently consolidate differently under traffic.

The effect of a dynamic track stabilizer on track strength was studied. The stabilizer was loaned to TTC from Union Pacific Railroad and is a Plasser type PTS-62. The stabilizer was operated by Union Pacific staff in cooperation with Plasser American Corporation representatives.

Exhibit 4 gives the results obtained from tests conducted on the HTL (wood ties and granite or traprock ballasts). In this exhibit, average deflection results



obtained on the tangent track and a 5-degree curve track are compared between well consolidated, newly tamped, and tamped and stabilized ballast conditions, respectively. Again, for both the tangent and curve tracks, tamping caused significant track strength reductions. This was exhibited by significant increases in lateral track deflection under the constant but moving vertical and lateral axle loads applied by the TLV. Use of the stabilizer on both the tangent and curve tracks led to a significant stabilizing effect on the ballast weakened by tamping. This effect is shown by smaller measured track panel deflections following stabilizer use than those measured on newly tamped tracks.

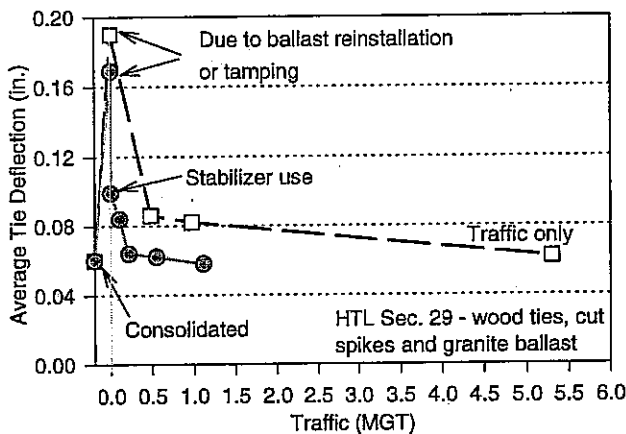


Exhibit 3. Effects of Ballast Tamping, Traffic- and Stabilizer-Induced Ballast Consolidation on Lateral Track Deflections due to Constant Moving Lateral and Vertical Loads

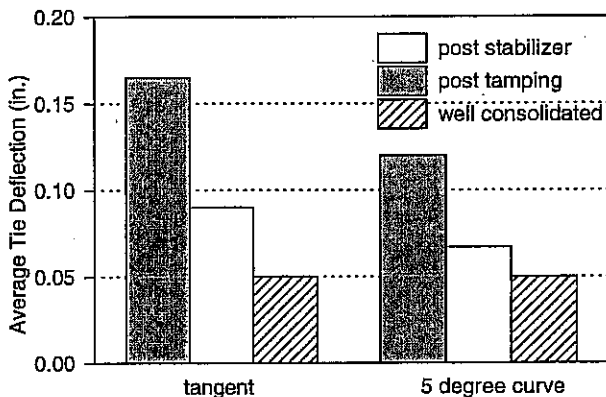


Exhibit 4. Effect of Dynamic Track Stabilizer on Lateral Track Deflection due to Constant Moving Lateral and Vertical Loads (Wood Ties, Cut Spikes and Granite/Traprock Ballast)

The equivalent effect of the stabilizer action due to train traffic was estimated based on the test results obtained on Section 29 of the HTL (Exhibit 3). Use of the stabilizer on the newly tamped granite track led to a strength recovery roughly equivalent to 0.3 MGT of traffic. Furthermore, with an additional 0.2 MGT of subsequent traffic following use of the stabilizer, the track was almost fully restored to its pre-tamping strength.

Benefits of a dynamic stabilizer may be compromised if the stabilizer does not function to its specifications. An assumption that proper stabilization will occur whenever ballast is visibly shaken is unfounded. Test results following initial use of an improperly adjusted but "still-vibrating" stabilizer demonstrated this.

Also, our limited test results concerning the stabilizer application on a newly tamped concrete-tie track suggest that more tests are required before sound conclusions can be drawn.

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Note: Contact Dingqing Li at (719) 584-0740 with questions or comments about this document.
E-mail: dingqing_li@aar.com

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