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Research Results

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The Influence of Track Maintenance on the Lateral Resistance of Concrete Tie Track

SUMMARY

It is well known that any track maintenance operation that disturbs the ballast section, such as surfacing (tamping), tie replacement, and ballast cleaning, will reduce track lateral resistance - and thus increase the track's susceptibility to buckling. Railroads typically employ traffic (tonnage applied at reduced speeds) or mechanical compaction provided by a dynamic track stabilizer (DTS) to quickly restore some of this lost lateral resistance.

Amtrak and the Federal Railroad Administration (FRA) jointly sponsored tests to measure and document the influence of track surfacing, DTS, and to a limited extent - traffic, on the lateral resistance of concrete tie track. During the tests, the DTS stabilized three different test sections at operating speeds of 0.7, 1.5, and 2.0 mph, respectively - all within the manufacturer's recommended range.

A summary of the test results is shown in Figure 1. Results indicated that surfacing (tamping) reduced the lateral track resistance to a range of about 52% to 63% of its initial level. DTS operation restored from 24% to 37% of the lateral resistance lost from surfacing, while the traffic passage of 3,360 gross tons (0.00336 MGT) restored about 13% of the lost resistance. Within the tested operating speed range, no clear variation in DTS effectiveness was evident.

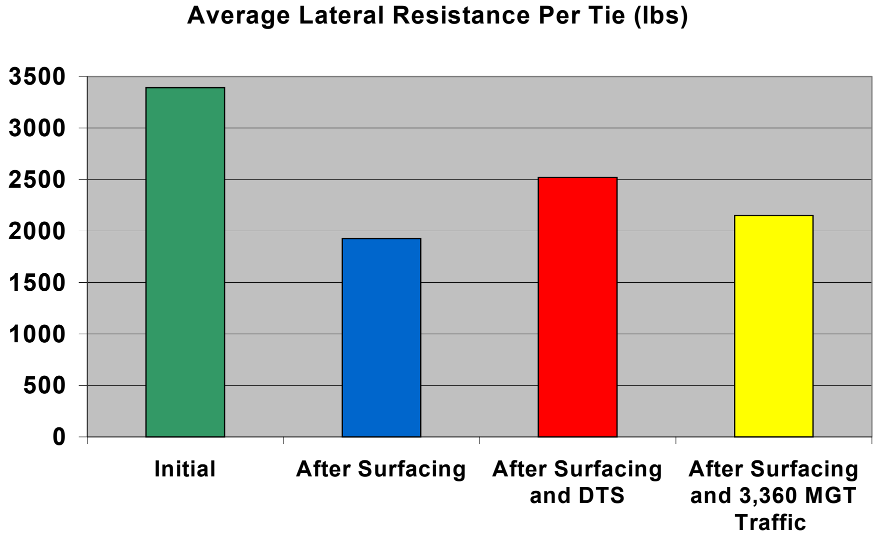

Average Lateral Resistance Per Tie (lbs)

Figure 1. Summary of Test Results

Note: DTS indicates stabilization using a dynamic track stabilizer.

BACKGROUND

Any track maintenance operation that disturbs the ballast section, such as surfacing (tamping), tie replacement, and ballast cleaning, will reduce track lateral resistance. This reduced lateral resistance can increase the track's susceptibility to buckling. Railroads typically employ traffic (train- applied tonnage at reduced speeds) or mechanical compaction from a dynamic track stabilizer (DTS) to quickly regenerate some of the lateral resistance lost from these maintenance operations.

Amtrak and the Federal Railroad Administration (FRA) jointly sponsored tests to measure and document the influence of track surfacing, dynamic track stabilization, and to a limited extent - traffic, on the lateral resistance of concrete tie track. These tests took place on Amtrak's Northeast Corridor in August 2001, near New Carrollton, MD. Testing and analyses were conducted through a joint effort of Amtrak, the Volpe National Transportation Systems Center (Volpe) and Foster-Miller, Inc. (FMI).

SOME TRACK BUCKLING BASICS

Railroad track is subjected to various forces from the environment, traffic, and maintenance, which the track structure must safely resist. When longitudinal forces in the rail are not adequately constrained by the lateral resistance of the track, a track buckle can occur. The main factors influencing track buckling are rail longitudinal force, track lateral resistance, track uplift occurring between the trucks of a rail vehicle, and lateral track alignment deviations.

Longitudinal rail force is the main driving factor for track buckling. When ambient temperature is high, rail temperature rises as well. Since thermal expansion of the rail is constrained, this temperature increase results in large compressive forces in the rail, which can cause the track to buckle laterally [1].

Resistance to buckling is provided mainly through the ballast surrounding the ties and the frictional forces developed between the ballast and the tie surfaces. This tie-ballast resistance can be divided into three components: tie bottom friction (F_b), tie side friction (F_s), and tie end or shoulder restraint (F_e) (Figure 2). All three vary with tie material, ballast type, ballast gradation, and tie-ballast interlock strength, which is partly a function of ballast compaction [2].

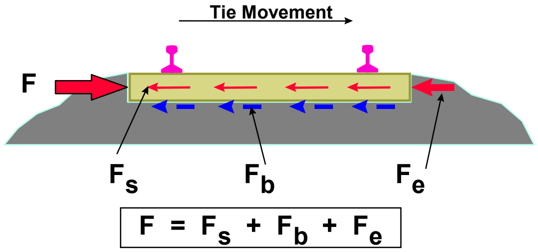


Figure 2. Tie Resistance Factors

THE TEST SITE

The tests were conducted on approximately 2,000 ft of Track 1, near MP 128. The test site was a relatively uniform, tangent track section with a slight grade change and vertical curve through the site. The track has concrete ties at 24 in. spacing and 140 RE rail fastened with the Pandrol Fastclip system. This track carries approximately 13 million gross tons (MGT) of freight traffic per year and is designated an FRA class 4 track. The ballast shoulder was wide, varying between 2 and 5 ft, with a gradual variation in width from one end of the site to the other. The shoulder extended level with the top of the ties for approximately 12 to 18 in., followed by a gradually slope to a point where it dropped off steeply.

HOW THE TESTS WERE CONDUCTED

Track lateral resistance was measured, first with the track in its original undisturbed state, and then after surfacing, DTS, and traffic passage. To capture the differing effects of traffic and DTS, these two operations were performed on separate parts of the test section.

During surfacing, the track was lifted about 0.4 in., with ballast added to fill the cribs. The stabilization was performed using a DTS operating at speeds of 0.7, 1.5, and 2 mph, respectively, in different test sections. Traffic was applied by operating a train consisting of an electric locomotive and 3 passenger cars passing over the test zone 12 times, at speeds between 5 and 20 mph, providing approximately 3,360 gross tons of traffic.

Lateral resistance was measured using the Single Tie Push Test (STPT). The STPT involves pushing an unfastened tie laterally in the ballast bed, measuring the force required to move the tie and the distance the tie was displaced. The resulting peak load (or force) defines the peak lateral resistance of the track. The STPT device (Figure 3) uses a hydraulic cylinder attached to a frame that reacts against the fastener base on the test tie. Load is measured using a calibrated pressure transducer, and a string potentiometer is attached to the rail to measure tie displacement.

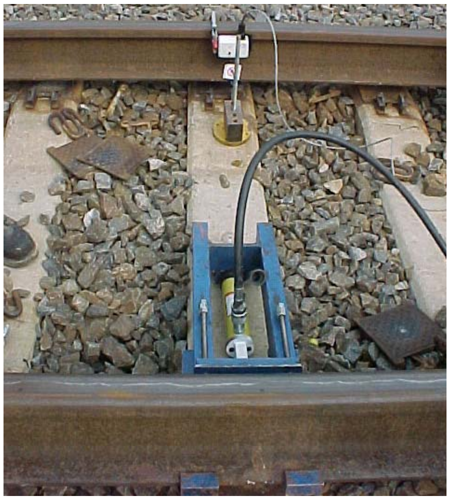


Figure 3. STPT Setup

Immediately following each STPT, the peak lateral resistance was noted and tabulated. After 10 tests, the mean, range, and standard deviation were calculated to ensure that the standard deviation did not exceed one-half the range of the values. STPTs were performed in four test sites so that variations in the stabilizer operating speed could be evaluated and compared to the effect of traffic. The total number of STPT tests performed over the test site is shown in Table 1.

Table 1. STPT Tests Performed

Test Stage	Number Of STPT Tests
Pre-surfacing	37
Post-surfacing	42
Post-DTS	35
Post-traffic	10

TEST RESULTS

Table 2 shows the average STPT values and standard deviations obtained for each of the four test stages.

The STPT measurements taken in the three DTS zones, representing the three DTS operating speeds (0.7, 1.5, and 2.0 mph), showed no significant difference, so these results were combined in Table 2. Any variation due to operating speed may have been masked by shoulder width variations throughout the site.

Table 2. Average Lateral Resistance Values

Test Stage	Average Lateral Resistance (lbs)	Standard Deviation (%)
Pre-surfacing	3393	9.7
Post-surfacing	1926	7.1
Post-DTS	2520	9.5
Post-traffic	2150	7.6

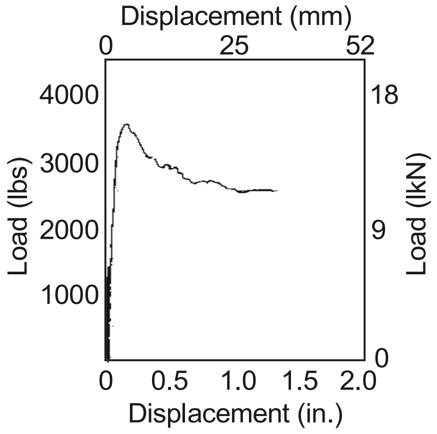
Figure 4 shows representative load-displacement graphs from the STPT measurements for the pre-surfacing, post-surfacing, and post-DTS stages. As shown in Figure 4A, common characteristics of the pre-surfacing tests are a steep initial slope, distinct peak, and a rapid post-peak decrease to a stable lateral resistance value approximately constant for large displacements. The distinct peak results from the ballast consolidation and tie-ballast interlock, which builds over time from the passage of many trains. Once the tie moves about 0.25 in., this tight consolidation and the tie-ballast interlock are lost, with resulting drop in resistance to movement.

The post-surfacing graph (Figure 4B) shows a gradual increase to a maximum value, with no distinct peak, resulting from the ballast disturbance during tamping. The post-DTS graph (Figure 4C), while generally similar in shape to the post-surfacing graph, shows an initial peak beginning to reform.

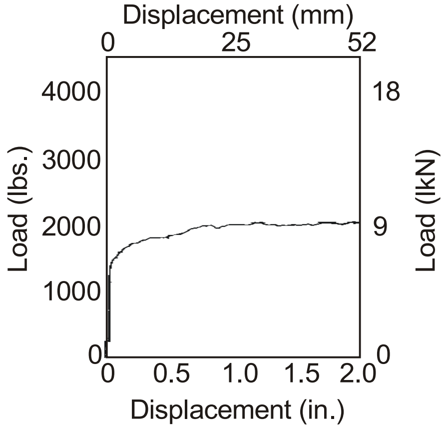
CONCLUSIONS

The test results indicated that surfacing (tamping) reduced lateral track resistance to a range of about 52% to 63% of its initial level. DTS operation restored from 24% to 37% of the lateral resistance lost from surfacing, while the traffic passage of 3,360 gross tons restored about 13% of the lost resistance. No clear difference in DTS effectiveness was evident within the operating speed range of 0.7 to 2.0 mph.

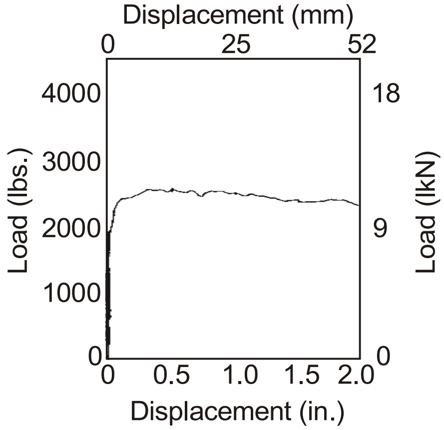
A more detailed discussion of the tests and results can be found in [3]. An assessment of how these lateral stability measurements relate to track buckling potential can be found in [4].



A) Pre-Surfacing



B) Post-Surfacing



C) Post-Stabilization

Figure 4. Representative STPT Load-Displacement Graphs

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[3] Sussmann, T., A. Kish, and M. Trosino (2003). “Investigation of the Influence of Track Maintenance on the Lateral Resistance of Concrete Tie Track,” Accepted for Presentation at the TRB Annual Meeting, Washington, D.C.

[4] Kish, A., T. Sussmann, and M. Trosino (2003). “Effects of Maintenance Operations on Track Buckling Potential,” Accepted for publication in the Proceedings of the International Heavy Haul Association, Specialist Technical Session, Dallas, TX.

ACKNOWLEDGEMENTS

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