

## POST-MAINTENANCE SPEED RESTRICTIONS AND DYNAMIC BALLAST STABILIZATION by William Shust, Dingqing Li, and Vin Terrill\*

### Summary

A two-year review of lateral strength tests shows that dynamic ballast stabilization can reduce the need for slow-order traffic following track maintenance. These tests were performed by Transportation Technology Center, Inc. (TTCI), engineers using TTCI's Track Loading Vehicle (TLV) primarily on Norfolk Southern (NS) railroad tracks.<sup>1,2</sup> Analysis of these tests and an industry survey include:

- The NS tests (wood ties with granite ballast) indicate that dynamic ballast stabilization is roughly equivalent to 90,000 gross tons of revenue freight traffic (some tests on TTC track have resulted in higher equivalences). In analyses presented in this article, the more conservative (90,000 tons) equivalence is assumed.
- From the industry survey it is apparent that when dynamic ballast stabilization is used, some railroads shorten the durations of post-maintenance train-speed restrictions. However, the survey shows that slow-order policies of railroads, both with and without stabilization vary.
- Without dynamic ballast stabilization, all 10 Class I railroads surveyed prescribe train operations of 25 mph or higher after 90,000 gross tons of vehicle traffic. Since a stabilizer is equivalent to at least this much traffic — based on limited TLV tests — it follows that 25 mph or higher may be a suitable minimum initial speed for high-density freight train operations following stabilizer use (subject to normal operating speeds).

North American railroads ensure safe and economical operations through significant investments in track inspection and regular maintenance, including ballast and tie replacement. However, when the interlocking ballast aggregate is disturbed, its ability to restrain the track from moving is sometimes temporarily reduced. For this reason, railroads commonly control their operations with temporary train-speed restrictions known as slow orders which unfortunately hinder traffic flow. A survey of current slow-order practices on high-density freight lines shows that prescribed baseline durations vary from 50,000 to more than 400,000 gross tons of vehicle traffic, with initial speed restrictions varying from 10 to 30 mph.

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- Planning & Analysis
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## INTRODUCTION AND CONCLUSIONS

Track maintenance may inadvertently and temporarily weaken the tie/ballast interface, prompting railroads to commonly control operations with temporary train-speed restrictions known as slow orders. This allows the ballast particles to settle and re-interlock, thus regaining strength with traffic. Unfortunately slow orders hinder traffic flow. Analyses of lateral track-strength tests performed by Transportation Technology Center, Inc. (TTCI), engineers indicate that dynamic ballast stabilization can reduce the need for slow-order traffic following track maintenance. Tests were conducted primarily on Norfolk Southern (NS) railroad tracks using TTCI's Track Loading Vehicle (TLV), shown in Exhibit 1.<sup>1,2</sup> Observations include:

- Dynamic ballast stabilization has been found to be equivalent to 90,000 gross tons of revenue freight traffic, with some closed loop tests on TTC track showing equivalencies up to 300,000 gross tons. In analyses presented in this Technology Digest, the more conservative (90,000-ton) equivalence is assumed.
- From the industry survey it's apparent that when dynamic ballast stabilization is used, railroads shorten the durations of post-maintenance train-speed restrictions. However, a technical comparison of slow orders with and without stabilization shows variations between the two alternatives for some railroads.
- Without dynamic ballast stabilization, all Class I railroads surveyed prescribe train operations of 25 mph or higher after 90,000 gross tons of vehicle traffic. Since a stabilizer is equivalent to at least this



Exhibit 1. TTCI's Track Loading Vehicle on Norfolk Southern track

much traffic — based on limited TLV tests — it follows that 25 mph or higher may be a suitable minimum initial speed for high-density freight operations following stabilizer use.

## CLASS 1 RAILROAD SLOW-ORDER SURVEY

Many railroads implement speed restrictions after ballast disturbances such as out-of-face tamping, ballast cleaning, or tie replacement. Other times, slow-orders may be in effect due to rail flaws and/or maintenance, bridge and structure repair work, and environmental extremes. This Technology Digest does not address speed restrictions other than those related to ballast or tie maintenance.

Slow orders are of particular interest when applied on heavy-density freight lines following out-of-face ballast disturbances in which continuous welded rail is expected to exceed rail neutral temperature. Understanding current speed restrictions is important to properly interpret experimental strength tests. Therefore, TTCI surveyed North American Class I freight railroads regarding train slow-orders on high-density lines after large ballast disturbances such as out-of-face surfacing, undercutting, or tie replacement. These apply to continuously welded rail over wooden ties when the rails are above neutral temperature. Due to industry mergers during the survey, slow-order policies outnumbered individual railroads.

Exhibit 2 shows various slow orders in North America. In the plot, the prescribed train speed is shown versus cumulative traffic in thousands of gross tons. For more-complex policies, the cases were studied which resulted in minimum traffic before returning to full track speed. For railroads specifying duration in hours only, 10 trains of 5,000 tons each were assumed per 24-hour period (18 million gross tons annually). As shown, current Class I slow-orders on heavy-density lines vary significantly. For example, the initial speed limit may range from 10 mph to 30 mph. Also the overall required traffic may vary from 50,000 to 400,000 tons.

Exhibit 3 reflects alternative policies employed by seven freight railroads when using dynamic ballast stabilization. When ballast stabilizers are used, slow-order durations are shorter than traffic-only operations. As shown, the initial prescribed speeds remain 10 to 30 mph; however, the required traffic

decreases (10,000 to 55,000 tons). For five of seven railroads, however, only one to three tonnage trains (5,000 tons each) are slowed after stabilization.

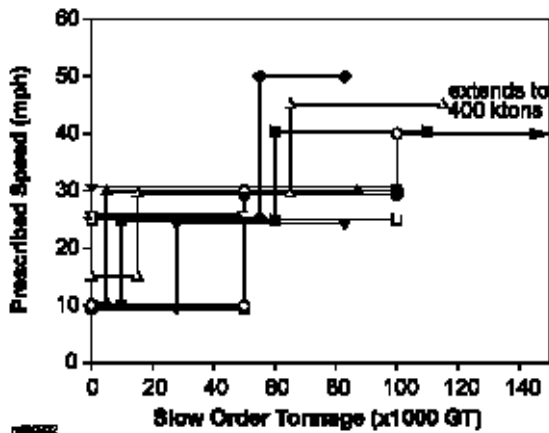


Exhibit 2. Baseline (Traffic Only) Class 1 Post-Maintenance Speed Restrictions

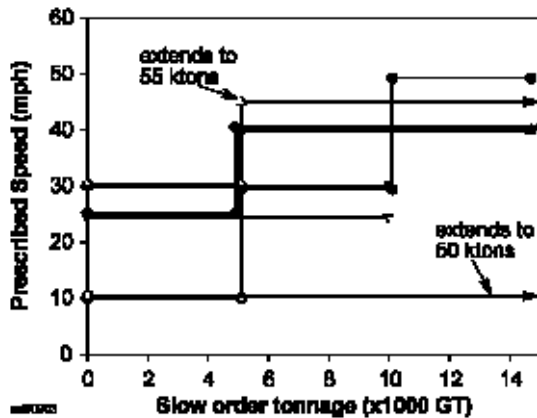


Exhibit 3. Shorter Speed Restrictions when Using Dynamic Track Stabilizer

**TRACK STRENGTH RESULTS AND COMPARISON OF SLOW-ORDER POLICIES**  
 At the Federal Railroad Administration's (FRA) Transportation Technology Center in early 1997, 12 wayside tie deflections were measured while the TLV panel shift system passed through a test zone at various levels of consolidation. Prior to any track work, the average of resulting tie deflections was 0.06 inch. After ballast tamping this deflection increased to 0.19 inch. Further results showed that the ballast stabilizer reduced the average tie deflection to that expected after 300,000 gross tons of closed loop FAST traffic.

Exhibit 4 summarizes further track-strength results obtained using stationary TLV tests at NS during 1997 and 1998. Results are shown for pre- and post-maintenance conditions, at various traffic levels, and for ballast-stabilizer operations. The data points show average strength found during each series, with vertical error bars showing a plus or minus one standard deviation band.

Overall, the average original strength at 0.1-inch tie deflection was 31,400 pounds. After maintenance, the strength was reduced to 17,900 pounds, or approximately 57 percent of the original. As the exhibit shows, approximately 100,000 tons of traffic is expected before a return to 70 percent of the original strength. On these tracks, use of the dynamic ballast stabilizer returned the strength to just under 70 percent of original, which was equivalent to 90,000 tons of traffic.

Some Class I freight railroads use alternative speed restrictions to account for the benefits of dynamic ballast stabilization. Ideally, for any railroad, these two policies (with stabilizer, versus without) would be equivalent. In other words, consolidation yielded by a traffic-only slow-order policy would be similar to the results of an (alternative) policy which accounts for benefits of stabilization.

A properly applied stabilizer has been shown to provide the equivalent of at least 90,000 gross tons of traffic. Therefore, it follows that the train operations prescribed after stabilization would be similar to operations prescribed after 90,000 tons of traffic. For the 10 railroads surveyed, all allow 25 mph or faster operation after 90,000 gross tons of traffic.

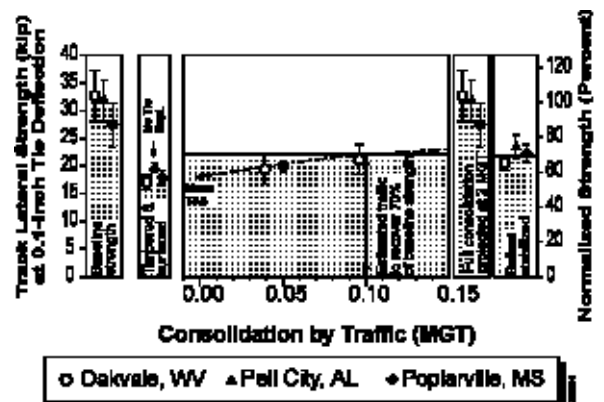


Exhibit 4. Combined Results from Three Series of TLV Field Tests at NS

To further check this balance, baseline (traffic-only) slow-order policies were compared with the traffic equivalence of a dynamic stabilizer plus the brief speed restrictions prescribed for post-stabilizer use. Therefore, Exhibit 5 compares the total equivalent traffic during either the baseline or stabilized slow-order policies.

If balanced, these alternatives would prescribe similar equivalent tonnage levels. However, this is not reflected from the survey. All of the six railroads using ballast stabilizers allow full track speed after an equivalent of 100,000 to 145,000 gross tons (stabilization plus an additional 10,000 to 55,000 tons). However, the baseline (traffic-only) requirements for these seven roads range from 85,000 to 400,000 gross tons before removing speed restrictions. This difference shows the possibility of additional optimization of certain policy alternatives.

**SUMMARY**

Over the past two decades, various North American railroads have shown a consistent decline in incidents related to lateral track instability. An important component of the successful track management strategies has been the implementation of post-maintenance speed restriction policies. However, because of infrastructure, environmental, seasonal, track structure, and train-operation differences

across the continent, no single slow-order policy should be suggested for all railroads. If a minimum strength is specified, field tests can help determine the proper slow-order policy. For example, if 70 percent of a well-constructed track's original strength is recommended before lifting a temporary speed restriction, this would correspond to a stationary TLV-measured strength (at 0.1 inch of tie deflection) of 22,000 pounds. This example would correspond to about 100,000 tons of slow-order traffic, of which a dynamic ballast stabilizer can produce the equivalent of 90,000 tons.

**REFERENCES**

1. Li, D., and Shust, W., "Investigation of Lateral Track Strength and Track Panel Shift using AAR's Track Loading Vehicle," R-917, Association of American Railroads, Transportation Technology Center, Pueblo, CO, December 1997.
2. Li, D.; Shust, W.; Thompson, R., and Cooke J., "Prototype Technique for Automated Lateral Track-Panel Strength Measurement," Technology Digest 98-013, Transportation Technology Center, Pueblo, CO, Association of American Railroads, April, 1998.

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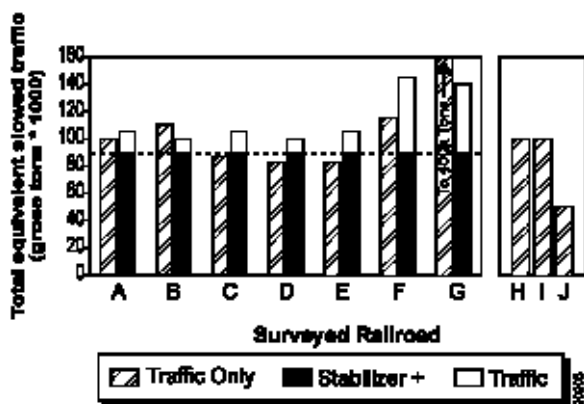


Exhibit 5. Slow-Order Comparison for Class 1 Railroads (Baseline versus Stabilizer Equivalent Traffic)

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