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Update: New Crosstie and Fastening System Test at the Facility for Accelerated Service Testing

SUMMARY

Transportation Technology Center, Inc. (TTCI), a wholly-owned subsidiary of the Association of American Railroads, in Pueblo, Colorado, has been evaluating and reporting on the evolution of premium railway crossties and fastening systems designed for heavy axle loads (HAL) since the beginning of the HAL Program in 1988. During this evaluation, suppliers have developed components that help extend the life of the ties and provide increased overall track strength and gage retention. The preliminary data presented here is for the newest crosstie and fastening system tests at Facility for Accelerated Service Testing (FAST).

TTCI observations at FAST conclude that the use of stronger components may lead to different failure modes. These are often more abrupt failures, such as a component fracture, rather than gradual gage widening.

The American Railway Engineering and Maintenance-of-Way Association (AREMA) 14-inch tie plate and cut spike system used with wood and plastic ties performed better than elastic fastening systems used with wood ties. New designs of tie plates for use with elastic rail fasteners were successful in eliminating plate fatigue in tests at FAST. High-strength screw spikes had considerably more failures than conventional screw spikes.

The high number of broken screw spikes and/or screw spike uplift in the elastic fastener test zones contributed to the loaded gage-widening degradation seen in those zones.

Tie plate cutting has not been a problem in the elastic fastening test zones. Generally, plate cutting is not a predominant failure mode for ties at FAST. However, failure of components, such as screw spikes allow increased lateral translation of the tie plates and more plate cutting.

All of these tests were on southern yellow pine crossties or Recycled Technologies International plastic ties. The lower density southern yellow pine ties accelerated the test results as compared to oak ties.

Figure 1. Southern Yellow Pine Crosstie Test Zone Installed at FAST

BACKGROUND

In 2004, TTCI began evaluating two elastic fastening systems. The NorFast system and the Pandrol Victor™ system with e-clips were installed in the 6-degree, 5-inch superelevation curve of the High Tonnage Loop (HTL) at FAST. These test zones were compared to two control zones of the same size (100 ties) installed at the same time. Both control zones consist of the same Pandrol 16-inch, rolled steel tie plate and e-clip system. Control Zone 1 uses LB&N Co's high-strength screw spikes (HS SS). Control Zone 2 uses standard No. 5760 screw spikes. These systems are being tested on solid sawn southern yellow pine ties to accelerate results.

In addition to the fastening system, a test zone was installed to evaluate the performance of the Recycle Technologies International (RTI) plastic ties fastened with cut spikes. A test of solid sawn southern yellow pine ties and parallel strand lumber ties with alternative-treatments was installed and fastened with cut spikes. All wood ties were treated with copper naphthenate (except for 20 ties with creosote). The steel-reinforced plastic ties that were installed in May of 2004 were mostly replaced by wood ties as a result of numerous broken-in-two type fractures.

NEW TESTS AT FAST

Tables 1 and 2 show the configuration of the new fastening system tests and the alternative treatment tests installed in the 6-degree curve of the HTL in 2004.

Table 1. New Fastening System Tests Installed in the HTL in 2004 — 415 MGT

~100-Tie Test Zones	Complementary Components		Expected Performance Benefit	Actual Performance
Pandrol™ Victor® Plate/ e-Clip Swaged System[1]	LB&N Co.™ High Strength Screw Spikes[1]	Solid Sawn Southern Yellow Pine Ties[2]	Extended tie plate life. Reduced screw spike uplift and fractures. Extended gage life Reduced tie plate cutting	No fractured tie plates 3% screw spikes uplifted 11% screw spikes fractured <10% over 57-1/4 in. loaded gage No plate cutting maintenance
Control Zone 1 Standard Pandrol™ 16-in. Rolled Steel Plate/ e-Clip System	LB&N Co.™ High Strength Screw Spikes[1]		Reduced screw spike uplift and fractures	14% fractured tie plates 7% screw spike uplifted 44% screw spikes fractured 50% over 57-1/4 in. loaded gage No plate cutting maintenance
NorFast ™ Cast Steel Plate/Rail-Clip System[1] with gage-widening resisting ribs	Standard 5760 Screw Spikes		Extended tie plate life Durable rail clips Extended gage life Reduced tie plate cutting	No fractured tie plates 3% rail clips fractured 50% over 57-1/4 in. loaded gage No plate cutting maintenance

[1] Donated by the suppliers [2] Donated by BNSF through Railway Tie Association (RTA)

Table 2. New Alternative Treatment Tie Tests Installed in the HTL in 2004 — 385 MGT.

Ties	Treatment	Expected Performance Benefit	Actual Performance
Parallel Strand Lumber Douglas Fir Southern Yellow Pine (20) [Cut Spiked]	Creosote	Base case	No fractured plates or cut spikes No cut spike uplift maintenance 100% over 57-1/4 in. loaded gage No plate cutting maintenance
Solid Southern Yellow Pine (96) [Cut Spiked]	Copper Naphthenate with CPT-2 (No. 2 oil) and BWR-5 (No. 5 oil)	Rot protection	No fractured plates or cut spikes No cut spike uplift maintenance 100% over 57-1/4 in. loaded gage No plate cutting maintenance No evidence of rotting. TTC is not a high rot environment
Parallel Strand Lumber Yellow Poplar Douglas Fir Southern Yellow Pine (60) [Cut Spiked]		Rot protection Reduced tie plate cutting	No fractured plates or cut spikes No cut spike uplift maintenance 100% over 57-1/4 in. loaded gage No evidence of rotting. TTC is not a high rot environment No plate cutting maintenance

Note: All the ties and their treatments were donated by RTA member suppliers.

PRELIMINARY PERFORMANCE

Fastening Systems

Maintenance performed in a test zone as a result of component failure or to comply with TTCI's track safety standards is an important system performance measure and is carefully documented. TTCI's track maintenance policy provides a guideline for performing track work (Table 3).

These test zones have been in service between 385 and 415 MGT. Maintenance records indicate that the 14-inch tie plate and cut spike system used on the solid sawn southern yellow pine and RTI plastic ties did not experience failures or require maintenance. The standard No. 5760 screw spikes used in the NorFast Zone and in Control Zone 2 required more maintenance to correct screw spike uplift than the two zones with LB&N Co. high-strength screw spikes. Seventeen of the new RTI plastic ties were rejected because their raised and swollen surfaces did not allow the tie plates to sit flat.

Broken screw spikes and tie plates (Figure 2) were a significant problem in Control Zone 1, where 44 percent of the tie plates had two or more broken LB&N Co. high-strength screw spikes and 14 percent of the Pandrol rolled steel tie plates fractured. A failure cycle may have been at work in this zone, where broken screw spikes contributed to the broken tie plates, which in turn led to more broken screw spikes. This type of tie plate, with its diagonally opposed e-clips, has a tendency to skew relative to the tie causing point loadings, which continue to result in increased plate fracture rates under HAL traffic at FAST.

Table 3. Required Maintenance Performed in the Fastening Systems Test Zones during 410 MGT

	Conditions Requiring Maintenance						
Test Zone	**Cut Spike Uplift >2 inches**	**Screw Spike Uplift >2 inches**	**Cut Spikes Broken >2/plate**	**Screw Spikes Broken >2/plate**	**Broken Plates**	**Broken or Sprung Rail Clips**	**Ties Gaged due to Wide Gage**
RTI Plastic, 14-inch (plates/cut spikes)	0	NA	0	NA	0	NA	0
Solid Southern Yellow Pine, 14-inch (plates/cut spikes)	0	NA	0	NA	0	NA	0
Pandrol Victor plates/e-clips, LB&N HS SS – Solid Southern Yellow Pine	NA	3% (63 of 800)	NA	11% (21 of 200)	0	0	0
Control 1, 16-inch Pandrol rolled plates, e-clips, LB&N HS SS – Solid Southern Yellow Pine	NA	7% (57 of 784)	NA	44% (86 of 196)	14% (28 of 196)	0	0
NorFast cast steel plates/clips, No.5760 SS – Solid Southern Yellow Pine	NA	13% (105 of 816)	NA	12% (25 of 204)	0	Sprung: 0 of 260. Broken: 3% (9 of 260)	0
Control 2, 16-in. Pandrol rolled plates, e-clips, No. 5760 SS – Solid Southern Yellow Pine	NA	8% (63 of 792)	NA	1% (2 of 198)	0	0	0

Figure 2. Component Failure under HAL Traffic (1) Pandrol 16-in. Rolled Steel Tie Plate (2) NorFast Rail Clip (3) LB&N Co. High Strength Screw Spike (4) No. 5760 Screw Spike

When two of the four screw spikes break, the screw spike holes in the plate and tie become oblong. The plate then is free to skew, subjected to point loading, and ultimately breaks. The remaining screw spikes react against higher, per screw spike loads that are introduced by lateral translation of the plates, which may result in spots of weaker track gage, higher per-component loadings, and a higher stress state.

LB&N Co. submitted independent laboratory results to TTCI on a single broken screw spike sample. The report suggested problems related to rolling laps from the threading process and decarburization. LB&N Co. indicated these issues are continually addressed and improved in their manufacturing process.

TTCI's current maintenance procedure is to cut spike tie plates where two or more screw spikes have fractured inside the tie as a preliminary remedial action. After a number of plates have been cut spiked, those plates are replaced with different screw spike patterns to provide higher track strength. To avoid the track component failure cycle, it is best to eliminate remedial action and replace the plates with four new screw spikes.

The LB&N high-strength screw spikes in the Pandrol Victor Zone and the standard No. 5760 screw spikes in the NorFast Zone performed similarly, where 11 and 12 percent of the tie plates, respectively, had two or more broken screw spikes. One percent of the tie plates in Control Zone 2 had two or more broken screw spikes. None of the Pandrol rolled steel tie plates in Control Zone 2 fractured. By comparison, 14 percent of the same type of tie plates used in Control Zone 1 fractured during the same period, perhaps due to the high number of broken screw spikes. None of the cast steel tie plates fractured in the NorFast Zone.

TTCI received NorFast rail clips from two different sources: one source not manufactured to proper specifications and the clips listed in Table 3 manufactured to the proper specifications, of which, none have sprung and 3 percent have fractured. Of the 148 out of specification clips still in track, 3 percent of the clips sprung and 7 percent fractured.

During the installation of the Pandrol Victor test zone, two of the rail clip shoulders became separated from their tie plates due to improper swaging, although some of the swaged shoulders have turned slightly. No other shoulder/plate separations occurred during the period of performance.

Track Gage-Spreading Strength

The track loading vehicle (TLV) was used to monitor track gage strength in the new test zones. Figure 3 shows the effect of HAL traffic on the loaded gage in the fastening system test zones. Six measurement cycles were taken under an applied 0.55 lateral/vertical (L/V) 18,000-/33,000-pound gage-spreading load at about 12 mph.

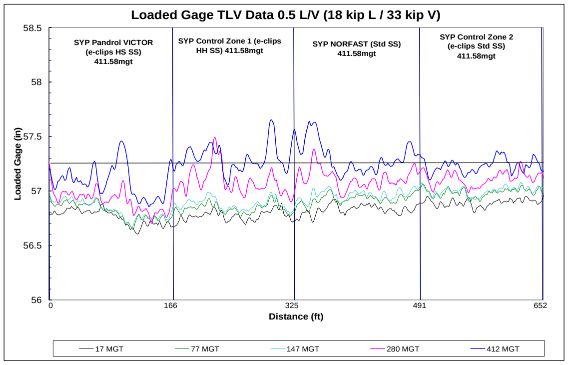

Figure 3. Fastening System Test Zones.

The initial average loaded gage measured in Control Zone 1 and in the NorFast test zone, after 17 MGT, was 56.77 and 56.83 inches. After 412 MGT of HAL traffic, the track gage exceeded 57.25 inches in more than 50 percent of each of the test zones under the dynamic gage spreading load of the TLV (degradation rates of 1/8 in/100 MGT to 3/16 in/100 MGT). This was likely a result of the high number of broken screw spikes in Control Zone 1 and the high number of screw spike uplift in the NorFast test zone.

Less than 10 percent of the Pandrol Victor test zone widened more than 57.25 inches, compared to almost 20 percent of Control Zone 2. The portion of the Pandrol Victor test zone that exceeded 57.25 inches, however, widened more (about 57.5 inches) than the widest portion of the control zone. This may have been due to the higher number of tie plates with more than two broken screw spikes in the Victor Zone (11 percent), as compared to Control Zone 2 (1 percent).

The elastic fastening system test zones required significantly more maintenance due to component failure and screw spike uplift than the alternative-treatment test zones and the RTI plastic ties with cut spikes; however, the elastic fastener zones retained better gage spreading strength than the alternative treatment test zones and the RTIs. After 382 MGT, 100 percent of the alternative treatment test zones and almost 93 percent of the RTIs exceeded 57.25 inches under the TLV load.

Tie Plate Cutting

Four fastening systems test zones show some indication of tie plate cutting, but none approached any maintenance threshold. Plate cutting in the Victor Zone was slightly more in places where several screw spikes fractured. Control Zone 1 was experiencing slightly more cutting where there were numerous broken screw spikes than Control Zone 2. Most of the tie plate cutting in the NorFast Zone occured on the field side of the low rail. A quantitative evaluation of tie plate cutting was performed after the ties were in service longer to allow for a more definitive comparison.

Two types of solvents were used in the copper naphthenate treatment of the parallel strand lumber species ties and the solid southern yellow pine ties. The two solvents are designated CPT-2 (No. 2 oil) and BWR-5 (No. 5 oil). Although some tie plate cutting was evident in all of these alternative treatment test zones, the ties treated with the BWR-5 solvent appeared to have a thicker and perhaps more durable protective surface layer than the ties treated with the CPT-2 solvent. The BWR-5 ties experienced less tie plate cutting.

Generally, the copper naphthenate treated solid southern yellow pine ties experienced less plate cutting than the copper naphthenate treated parallel strand lumber. The southern yellow pine parallel strand lumber with creosote experienced less plate cutting than Douglas fir ties with creosote.

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