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Update: New Crosstie and Fastening System Test at FAST

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Summary

Transportation Technology Center, Inc. has been evaluating and reporting on the evolution of premium railway crossties and fastening systems designed for heavy axle loads since the beginning of the Heavy Axle Load Program in 1988. During that time, suppliers have developed components that help extend the life of the ties and provide increased overall track strength and gage retention. The preliminary data reported here is for the newest crosstie and fastening system tests at FAST (Facility for Accelerated Service Testing).

Observations

- 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.

Component Failures and Required Maintenance:

- The AREMA 14-inch tie plate and cut spike system used with the wood and the plastic ties performed better than the elastic fastening systems used with the wood ties relative to component failures and maintenance. There were no component failures and no maintenance was required in the cut spike system zones over the 400 MGT period of the test.
- New designs of tie plates for use with elastic rail fasteners were successful in eliminating plate fatigue in tests at FAST. The new designs had no fractures, whereas the conventional plates had 14 percent failure in 400 MGT of 39,000-pound wheel load operations.
- In direct comparison of plate hold-down fasteners, high-strength screw spikes had considerably more failures than conventional screw spikes. These comparisons were conducted with a widely used plate and rail fastener system.
  - The new plate and fastener designs did reduce, but not eliminate, high-strength screw spike breakage in the test

Track Gage-Spreading Strength:

- The elastic fastening systems performed better than the cut spiked systems relative to loaded track gage widening, especially up to the point where components begin failing. After about 400 MGT, virtually all of the cut spike tests (alternative wood treatments and the RTI plastic ties) had loaded gage above 57 1/4 inches and loaded gage degradation rates above 3/16 inch per 100 MGT. The elastic fastener tests had loaded gage above 57 1/4 inches in 10 to 50 percent of the test sections (degradation rates of 1/8 in/100 MGT to 3/16 in/100 MGT.
- 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:

- 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 the above tests were on southern yellow pine crossties, except for the Recycled Technologies International plastic ties. Southern yellow pine ties accelerated the test as compared to oak ties.

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INTRODUCTION

In 2004, Transportation Technology Center, Inc. (TTCI) began evaluating two elastic fastening systems never before tested on site. 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 are being 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, however, uses the LB&N high strength screw spikes (HS SS) and Control Zone 2 uses the standard No. 5760 screw spikes. These systems are being tested on solid sawn southern yellow pine ties to accelerate the test results.

In addition to the fastening system tests, a test zone was installed to evaluate the performance of the Recycle Technologies International (RTI) plastic ties fastened with cut spikes. A test of wood ties with alternative-treatments was also installed. The solid sawn southern yellow pine ties and the parallel strand lumber ties with alternative treatments are fastened with cut spikes. Copper naphthenate was used to treat all of the solid sawn ties and the parallel strand lumber ties (except for 20 treated with creosote). The steel-reinforced plastic ties that were installed in May of 2004 have been almost completely 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

Test ~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 Std. 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	Std. 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

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 (#2 oil) and BWR-5 (#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 that is performed in a test zone as a result of component failure or to comply with TTCI's track safety standards is an important measure of system performance and is carefully documented. TTCI's track maintenance policy provides the triggers shown in the column headings of Table 3 as a guideline for performing track work.

The test zones shown in Table 3 have been in service between 385 MGT and 415 MGT. During that period, the maintenance records indicate that the 14-inch tie plate and cut spike system used on the solid sawn southern yellow pine ties and on the RTI plastic ties did not experience failures and did not 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 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 broken tie plates, as shown in Figure 1, were a significant problem in Control Zone 1, where 44 percent of the tie plates had two or more broken LB&N high strength screw spikes and 14 percent of the Pandrol rolled steel tie plates fractured. It appears 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. The skewing causes point loadings, which continue to result in increased plate fracture rates under heavy axle load (HAL) traffic at FAST. Given that, when two of the four screw spikes break, the screw spike holes in the plate and in the tie become oblong, the plate is freer to skew, it is subjected to point loading, and it ultimately breaks. The remaining screw spikes are then left to react against higher, per screw spike loads that are introduced by lateral translation of the plates.

This may result in spots of weaker track gage, higher per-component loadings, and a higher stress state.

LB&N submitted the result of a test conducted by an independent laboratory to TTCI on a single broken screw spike sample. The lab's report suggested problems related to rolling laps from the threading process and decarburization. LB&N indicated these issues are continually addressed and improved in their manufacturing process.

Figure 1. Component Failure under HAL Traffic (1) Pandrol 16-in. rolled steel tie plate (2) NorFast rail clip (3) LB&N High Strength Screw Spike (4) No. 5760 Screw Spike

TTCI's current maintenance procedure is to cut spike those tie plates where two or more screw spikes have fractured inside the tie. This is done as a preliminary remedial action. After a number of plates have been cut spiked due to broken screw spikes, those plates are replaced with ones of a different screw spike pattern. To avoid the track component failure cycle, the tie plate cutting, and the track gage degradation that was seen under HAL traffic in Control Zone 1, it is likely best to eliminate the preliminary remedial action step (cut spiking the plates) and to proceed directly to replacing the plates using four new screw spikes.

The right tie in Figure 2 shows a tie plate that was cut spiked after two screw spikes broke off inside the tie. The left tie is providing higher track strength. The tie was refitted with a plate of different screw spike pattern where all four screw spikes can be used again.

Figure 2. Right Tie: Cut Spiked after Two Screw Spikes Broke Off Inside the Tie. Left Tie: Providing Higher Track Strength with All Four Screw Spikes in New Holes

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 has fractured. By comparison 14 percent of the same type of tie plates used in Control Zone 1 fractured during the same period. This may have been due to the high number of broken screw spikes in Control Zone 1. None of the cast steel tie plates has fractured in the NorFast Zone.

TTCI received NorFast rail clips from two different sources. NorFast representatives explained those from one source were not manufactured to the proper specifications. The NorFast clips listed in Table 3 were manufactured to the proper specifications. The maintenance record shows that none have sprung and 3 percent have fractured. Of the out of spec clips still in track, 3 percent (4 of 148) have become sprung and 7 percent (11 of 148) have fractured.

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

	Conditions Requiring Maintenance						
Test Zone	Cut Spike Uplift >2"	Screw Spike Uplift >2"	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-in. plates/cut spikes	0	NA	0	NA	0	NA	0
Solid Southern Yellow Pine, 14-in. 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-in. 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, #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, #5760 SS – Solid Southern Yellow Pine	NA	8% (63 of 792)	NA	1% (2 of 198)	0	0	0

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, there have been no other shoulder/plate separations during the period of performance

Track Gage-Spreading Strength

The 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. The six measurement cycles were taken under an applied 0.55 L/V (18,000 lb lateral/33,000 lb vertical) gage-spreading load at about 12 mph.

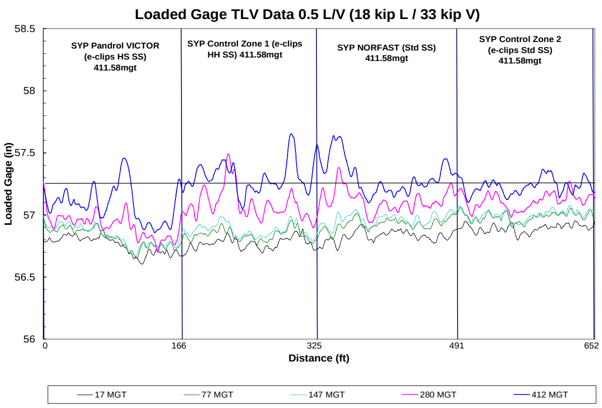

Figure 3. Loaded Gage Measured in the Fastening System Test Zones under the 0.55 L/V TLV Gage Spreading Load at 12 mph

The initial average loaded gage measured in Control Zone 1 and in the NorFast test zone, after 17 MGT, was 56.77 inches and 56.83 inches, respectively. After 412 MGT of HAL traffic, however, the track gage exceeded 57 1/4 inches in more than 50 percent of each of these test zones under the dynamic gage spreading load of the TLV. This gage widening 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 1/4 inches compared to almost 20 percent of Control Zone 2. The portion of the Pandrol Victor test zone that exceeded 57 1/4 inches, however, widened more (about 57 1/2 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%) as compared to Control Zone 2 (1%).

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 1/4 inches under the TLV load.

Tie Plate Cutting

Four fastenings systems are being evaluated on southern yellow pine ties to accelerate the tests. The four test zones are showing some indications of tie plate cutting, but none is approaching any maintenance threshold. Plate cutting in the Victor Zone is slightly more in places where several screw spikes have fractured allowing increased lateral translation of the plates. There is very little cutting in Control Zone 2. Control Zone 1 is experiencing slightly more cutting than Control Zone 2, especially where there have been numerous broken screw spikes. Most of the tie plate cutting in the NorFast Zone is occurring on the field side of the low rail. A quantitative evaluation of the tie plate cutting will be performed after the ties have been in service a longer period 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 is evident in all of these alternative treatment test zones, the ties treated with the BWR-5 solvent appear to have a thicker and perhaps more durable protective surface layer than the ties treated with the CPT-2 solvent. The BWR-5 ties also appear to be experiencing less tie plate cutting, as Figure 4 shows.

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

Figure 4. Two Southern Yellow Pine Parallel Strand Lumber Ties Treated with Copper Naphthenate. Tie No. 534 Treated with CPT-2 Solvent. Tie No. 535 Treated with BWR-5 Solvent Appears to have a Thicker Protective Layer and Experiencing Less Tie Plate Cutting

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