TECHNOLOGY DIGEST

Timely Technology Transfer — 02-004

Progress Report: In-Track Performance Testing of Plastic Composite Ties at FAST

by Rafael Jimenez, David Davis, and Joseph LoPresti

Summary

Plastic composite ties of two manufacturers have been able to withstand heavy axle loads for more than 500 million gross tons (MGT) in limited, short zone testing. The ties are performing with positive results in full-size, 100-tie, out-of-face testing and in plastic tie/wood tie intermixed testing. Transportation Technology Center, Inc., (TTCI) a subsidiary of the Association of American Railroads, is monitoring the performance of the ties under 39-ton axle loads at the Federal Railroad Administration's Facility for Accelerated Service Testing (FAST), Pueblo, Colorado. The ties were manufactured by TieTek, Inc. and U.S. Plastic Lumber Ltd. (USPL).

In preliminary testing, using short test zones in a 5-degree curve, 25 smooth-sided USPL ties have been in track for 591 million gross tons (MGT); 25 rough-sided USPL ties have accumulated 513 MGT; and 20 smooth-sided TieTek™ ties have been in service for 504 MGT. In the more severe lateral load environment of a 6-degree curve, the full-size, 100-tie, rough-sided TieTek™ test zone has seen just over 200 MGT of traffic and the TieTek™ intermixed zone has accumulated 106 MGT.

One advantage of rough sided ties is their initial high lateral strength and resistance to track buckling. After track consolidation by 10 MGT of traffic, the lateral resistance measured on the rough-sided ties of both manufacturers was about 60 percent higher than that measured on wood ties with the same tonnage.

There has been some screw spike or cut spike uplift in ties from both manufacturers. Cracks that occurred during installation in some of the USPL and TieTek™ ties, due to small diameter screw spike pilot holes, have not grown significantly. Neither condition has resulted in any ties being removed from track. There is no evidence of cracking or of the screw spikes working upward in the TieTek™ plastic/wood tie intermixed zone where 11/16-inch pilot holes were used.

The thermal expansion properties of plastic ties have resulted in a slight increase in track gage during warm months at FAST. TTCI will continue to monitor the effect that thermal expansion may have on the long-term track geometry, gage retention, and gage spreading strength of plastic tie track.

Suggested Distribution:

- ❑ Maintenance of Way
- ❑ Planning & Analysis
- ❑ Track Maintenance
- ❑ Safety

Work performed by Transportation Technology Center, Inc.
a subsidiary of the Association of American Railroads

BACKGROUND

The plastic composite tie designs from TieTek, Inc. and U.S. Plastic Lumber Ltd. (USPL) have performed well in short, preliminary test zones, and more recently in full-size test zones, under 39-ton heavy axle load (HAL) traffic. Transportation Technology Center, Inc. (TTCI) installed the ties in the High Tonnage Loop (HTL) at the Facility for Accelerated Service Testing (FAST). FAST is a part of the Federal Railroad Administration's (FRA) Transportation Technology Center, Pueblo, Colorado.

PRELIMINARY TEST ZONES

Prior to the full-size, 100-tie, out-of-face plastic tie installation currently in HTL Section 25, preliminary test zones of ties from the two manufacturers were installed in the less severe environment of HTL Section 7. The preliminary, shorter length test zones in the 5-degree, 4-inch superelevation curve provided a more controlled and safe environment in which to monitor, for the first time on the HTL, the overall in-track performance of plastic ties. In addition, the preliminary test zones provided:

- Data that led to the design and development of the roughened-surface plastic tie, which increased single-tie lateral resistance significantly.
- A safe environment in which to experiment with different screw spike pilot hole sizes.
- The opportunity to study the behavior of crack growth using cracks that developed as a result of small-diameter screw spike pilot holes.

USPL Plastic Ties

The USPL plastic tie preliminary test zone installed in May 1997 in Section 7 of the HTL consists of 25 smooth-sided and 25 rough-sided ties. The preliminary USPL plastic ties that have been in track longest have accumulated 591 MGT (241 MGT under low lateral load steering trucks). This preliminary 50-tie test zone, fastened with Pandrol® screw spikes and e-clip fasteners, is half of a typical full-size test zone.

TTCI experimented with different pilot hole sizes for screw spike installations. Test results show that cracks develop when 5/8-inch diameter pilot holes are used with 15/16-inch screw spikes in both the USPL ties and the TieTek™ ties. Pilot holes made to a 3/4-inch diameter did not result in cracks but allowed some of the screw spikes to work upward. The 11/16-inch diameter pilot holes being monitored in the intermixed TieTek™/wood tie test zone in HTL Section 25 are providing better holding power thus far—none of the screw spikes have worked upward, and no cracking has occurred. To date, there have been no gage-widening or track geometry problems.

TieTek™ Plastic Ties

The second preliminary test zone in HTL Section 7 was installed in January 1998. The 20-tie TieTek™ preliminary test zone has accumulated 504 MGT (173 MGT under low lateral load steering trucks) without gage widening, cracking, or track geometry problems. The ties in this zone are fastened with cut spikes. To date, no cut spike maintenance has been required due to uplift.

Resistance to Lateral Movement

Single-Tie Push Tests (STPT) are performed to determine the resistance to lateral movement through the ballast section that a particular tie type provides. STPT results provide an indication of the potential lateral stability of track equipped with the type of ties tested.

The first-generation plastic ties installed on the HTL had smooth surfaces on all four sides. The results of the first STPTs performed by TTCI showed that the single-tie lateral resistance of the smooth ties was significantly lower than that of typical solid-sawn wood ties. Those results led the manufacturers to develop the roughened plastic tie.

To facilitate the tie's interaction with the ballast, thereby increasing the resistance to lateral movement, both manufacturers roughened their ties with raised welts on the two sides and on the bottom. Exhibits 1 and 2 show that both TieTek, and USPL used a similar approach.

Exhibit 3 compares the results of single tie lateral resistance tests performed on smooth plastic ties, on solid sawn wood ties, and on the roughened ties of both manufacturers. The lateral resistance plotted in each case is the average peak resistance for the first 1 inch of lateral tie displacement. The tests were performed when the ties were newly installed to measure early strength and again after 10 MGT of HAL traffic when the steady state of lateral resistance is considered to have been achieved.

The graph shows that roughening the two sides and the bottom of the USPL plastic ties increased the single-tie resistance to lateral movement of newly installed ties by more than a factor of 3 over smooth-sided ties. After consolidation by 10 MGT of traffic, the lateral resistance measured on the rough-sided ties of both manufacturers was about 60 percent higher than that measured on wood ties with the same tonnage. The smooth-sided plastic ties, after 10 MGT of traffic, had 40 percent less lateral resistance than wood ties with the same tonnage.

Exhibit 1. TieTek™ Plastic Ties with Roughened Surfaces, Fastened with Cut Spikes in HTL Section 25

Exhibit 2. USPL Plastic Ties with Roughened Surfaces and Elastic Fasteners in HTL Section 7

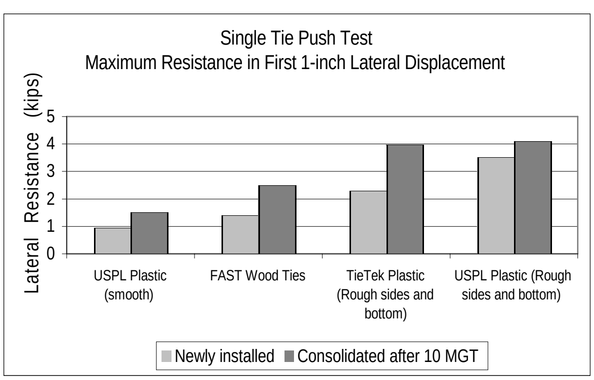

Exhibit 3. Single Tie Push Test (STPT) Results Show Resistance to Lateral Movement

FULL-SIZE TEST ZONES

A 100-tie test zone is considered to be the minimum needed to determine the likely performance of ties in HAL revenue service applications. The 100-tie zones limit the effects of transitions to other sections and provide enough track to see a wide range of dynamic conditions. Exhibit 4 shows the HAL environment on the HTL where the full-size, out-of-face and intermixed test zones are located.

Exhibit 4. HAL Environment on the HTL, Full-Size, Out-of-Face and the Intermixed Test Zones

Track Geometry	6-degree, 5-inch superelevation curve
Ballast Section	AREMA 4A granite - nominal 18-inch depth, 15-inch shoulders
Tie Spacing	19.5 inches on center
Rail Section	136-lb. RE welded rail
Train	70 to 80 315,000 lb. (39-ton axle load) cars
Operating Speed	40 mph, about 1.7-inch overbalance speed
Avg. High Rail Lateral Load	About 12 kips
Accumulation of Tonnage	Over 100 MGT per year
Climate	Semi-arid

TieTek™ Plastic: Out-of-Face, 207 MGT

The TieTek™ plastic tie out-of-face test zone consists of 100 consecutive ties (about 164 track feet). The ties are fastened using American Railway Engineering and Maintenance of Way Association (AREMA) 14-inch tie plates and cut spikes in 3/8-inch pilot holes.

The cut spike pattern used on both rails in this test zone is typical of that used in curves. That is, two diagonally opposed hold-down spikes, two rail spikes on the gage side, and one rail spike on the field side. Soon after the HAL train began operations on the newly installed test zone, the majority of spikes in the hold-down and rail positions began to work upward. Currently, cut spike uplift is between 3/8 and 1/2 inch.

Cut spike withdrawal resistance tests were performed on the TieTek™ plastic ties using a 3/8-inch diameter pilot hole — the same as that used for the out-of-face installation. The average withdrawal resistance measured was 3,200 pounds. By comparison, the average cut spike withdrawal resistance measured on new red oak solid sawn wood ties during a previous test, where no pilot holes were used, was about 8,600 pounds.[1]

TTC = Transportation Technology Center; FAST = Facility for Accelerated Service Testing

Gage-spreading strength was measured under dynamic 0.5 L/V loading (18-kip lateral / 33-kip vertical) using TTCI's Track Loading Vehicle (TLV). The graph of Exhibit 5 shows the results of four gage-spreading strength measurement cycles. The first two measurements were taken during the typically low-temperature months of October and February. The third measurement was taken in June when ambient temperatures can reach above 90°F. The fourth and most recent measurement was taken in February when the ambient temperature again is typically colder at TTC.

Data indicates that under the same load conditions, the loaded track gage increased about 0.24 inch during the higher temperature measurement cycle. Tests to determine the coefficient of thermal expansion were performed on the test ties by TTCI and the manufacturer. The results indicate that an increase in tie length of 0.24 inch can be reasonably expected.

To study the long-term effect of cyclic thermal expansion and contraction in plastic composite tie track, TTCI will continue to test and monitor changes in geometry, gage retention, and gage-spreading strength over the normally occurring temperature range

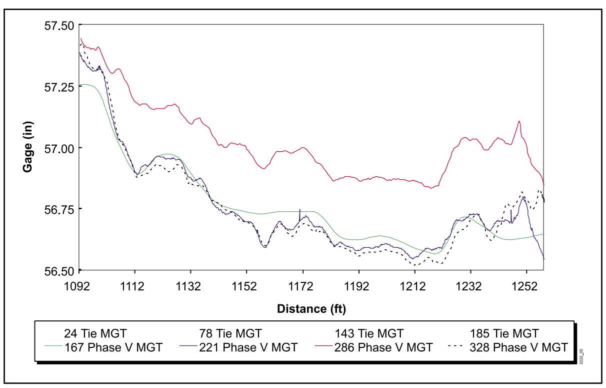

Exhibit 5. Loaded Gage, TieTek™ Plastic Tie Test Zone Fastened with Cut Spikes

Intermixed TieTek™ Plastic Tie/Wood Tie Test Zone, 106 MGT

The TieTek™ plastic tie/wood tie intermixed test zone consists of 174 ties (about 284 track feet) where 54 plastic ties (30 percent) are intermixed with existing solid sawn wood ties to simulate a major tie renewal operation. In the major portion of the test zone, both the plastic and the wood ties are fastened with AirBoss® tie plates and elastic fasteners with Lewis Bolt & Nut Co. (LB&N) high strength screw spikes in 11/16-inch pilot holes.

TLV loaded gage test results show that there has been no significant change in gage spreading as a result of intermixing. Installed using 11/16-inch pilot holes, none of the high strength LB&N screw spikes have worked up in the plastic or in the wood ties, and none have fractured.

SUMMARY

Being engineered products, the compositions and manufacturing processes of plastic composite ties are likely to differ from one manufacturer to another. It is important to note, therefore, that such differences may have an effect on the performance of plastic ties.

TTCI will continue to study the long-term, in-track performance of plastic ties in the heavy axle load environment of the HTL at FAST to determine their failure mode(s) and life cycle.

ACKNOWLEDGEMENT

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REFERENCE

Davis, David D., et al., "The Effects of Weathering on Wooden Crossties," R-915, Association of American Railroads, Washington, D.C., December 1997.

Note: Please contact Rafael Jimenez at (719) 584-0691 with questions or comments about this document.
E-mail: rafael_jimenez@ttci.aar.com
Web site: www.ttci.aar.com

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