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# Preliminary Performance of Plastic Ties in Revenue Service at the Eastern Mega Site (Norfolk Southern)

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**Summary**

As part of the Heavy Axle Load (HAL) Revenue Service Testing Program funded by the Association of American Railroads (AAR) and the Federal Railroad Administration (FRA), a plastic tie test zone (including two types from two manufacturers) was installed in a 6.8-degree curve at the Eastern Mega Site (Norfolk Southern) between Narrows, VA and Bluefield, WV in November 2004. The test zone has been subjected to approximately 70 million gross tons (MGT) to date under mostly 286,000-pound coal traffic. The following are the preliminary results and observations:

- The plastic ties at the NS Mega Site have been able to withstand HAL traffic with acceptable performance.
- As a result of spiking without pilot holes, 40 cracks (3 percent of all spike locations) developed in the 150 plastic ties during installation:
  - Most of the cracks occurred in the ties from one manufacturer.
  - The cracks have not had a significant effect on the performance of the ties.
  - Spike maintenance has not been required.
  - None of the ties has fractured.
  - Plastic material buildup around spike holes kept the tie plates from seating flat on the ties.
- Use of pilot holes (when replacing 9 ties with severe cracks) prevented occurrences of cracks and reduced the plastic material build up around spike holes.
- The effect of seasonal (temperature) change on track gage of the plastic ties is not significant.
- The average gage spreading due to static test load in the plastic ties was approximately 25 percent higher (i.e., lower gage strength) than in the new mixed hardwood tie control zone after 50 MGT (both fastened with cut spikes). However, the maximum delta gage in plastic ties was less than 0.25 inch.
  - The dynamic (under train) railhead lateral displacements measured in the plastic ties were about 2 times higher than those measured in the new wood ties.
- Although the plastic ties have experienced a reduction in gage strength during the first 50 MGT, additional measurements are needed after more tonnage is accumulated to determine if a steady state in gage strength will occur as was the case at FAST.
- The preliminary performance results of plastic ties observed at the NS mega site have been similar to the results obtained for the same plastic ties being tested at FAST.

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## INTRODUCTION

Under the HAL Revenue Service Testing Program funded by AAR and FRA, two test mega sites were established in revenue service in 2004-2005: one in the east on a Norfolk Southern (NS) mainline and the other in the west on a Union Pacific (UP) mainline. At these two mega sites, a number of experiments have been started and are still continuing.[1] The main objective of these experiments is to test and monitor new technologies and track materials and components intended to mitigate the adverse effects of HAL on track degradation (stress state). This *Technology Digest* reports the preliminary performance of the plastic ties installed on the Norfolk Southern Mega Site in November 2004.

Wood has been the preferred material for use in railway crossties for a long time, and it continues to dominate the market. Projections indicated that 90 percent of ties installed in 2005 would be wood.[2] During the past decade, however, manufacturers of ties made from plastic composite materials have been developing an alternative that promises to provide the three basic functions: to hold gage, to maintain surface, and to maintain alignment, with the added benefit of resisting damage caused by insects and moisture. In 2004 about 66,000 plastic ties were installed on Class I railroads. As reported in *RT&S*, projections for 2005 indicated about 250,000 plastic ties would have been installed.[2]

TTCI has been monitoring the in-track performance of plastic composite ties under HAL traffic on the High Tonnage Loop (HTL) at FAST since 1997 under more than 1,000 million gross tons (MGT). Generally, the plastic ties tested at FAST have been able to withstand 39-ton axle loads (315,000-pound gross weight vehicles) in out-of-face (consecutive-tie) installations and intermixed with wood ties. The focus of the plastic tie test at the NS mega site is to evaluate the performance of these ties on an active HAL coal route under the typical track geometry, train handling, and environmental conditions that exist in revenue service, but not at FAST

### Test Zone at NS Mega Site

The test zone was installed in a 6.8-degree curve between Narrows, VA and Bluefield, WV in November 2004. It consisted of three adjacent subzones: two 75-tie plastic composite test sections with a 75-tie solid-sawn NS standard mixed hardwood control section in between. Table 1 shows the test environment.

### Preliminary Performance Results

#### Tie Cracking due to Spiking without Pilot Hole

The plastic composite ties were fastened using NS standard 8 x 18 inch cut spike tie plates and typical tie-gang equipment with a rapid-impact type production spiker. At the recommendation of the manufacturers, the spikes were driven into the ties without pilot holes. As a result of spiking, cracking in the rail seat area occurred in about 4.5 percent (34 of 750) of the spike locations in one manufacturer's plastic ties, as Figure 1 shows. Six cracks, less than 1 percent of the spike locations, also occurred in another manufacturer's plastic ties. Nevertheless, none of the cracked ties from either manufacturer fractured.

**Table 1. Test Environment & Installation of Plastic Tie Test Zone on NS Mega Site**

| | |
|---|---|
| Test Zones (75 ties each) | Polywood, Inc. (test)<br>TieTek, Inc. (test)<br>Solid-sawn mixed hardwood (control) |
| Location | MP N353.6 Track #1 – Narrows to Bluefield Mainline |
| Traffic | Primarily 286,000-lb. coal loads @ maximum speed 30 mph |
| Track Geometry | 6.8-degree curve<br>2.5-inch superelevation<br>0.8% grade<br>1.3-inch cant deficiency |
| Fastening System | 8-in. x 18-in. NS std. cut spike tie plates |
| Installation | Out of Face (consecutive ties) |
| | Standard wood-tie gang equipment (rapid-impact type gang spiker) |
| | NO PILOT HOLES |

**Figure 1. Typical Crack in Rail Seat Area as a Result of Spiking without Pilot Holes**

Nine of the plastic ties (from one manufacturer) that cracked during the initial installation were later replaced as a precautionary measure. However, none of the nine ties removed were fractured. During the replacement, the nine new ties were drilled with 3/8-inch-diameter x 3-inch-deep pilot holes to prevent cracking.

Over the early phase of the test, more cracks developed and some existing cracks have grown. But the cracks thus far have not had a significant effect on the performance of the ties. Also, spike maintenance has not been required and there have been no tie fracture problems.

Another issue associated with spiking without pilot holes was the plastic material flow up from the spike holes. Figure 2 shows an example of the plastic material that built up between the bottom of the tie plates and the top of the ties around the spike holes during spiking where pilot holes were not used. Note that for the nine ties replaced with pilot holes, the amount of buildup was reduced greatly.

**Figure 2. Plastic Material Buildup that Occurred as Spikes were Driven into Ties 1**

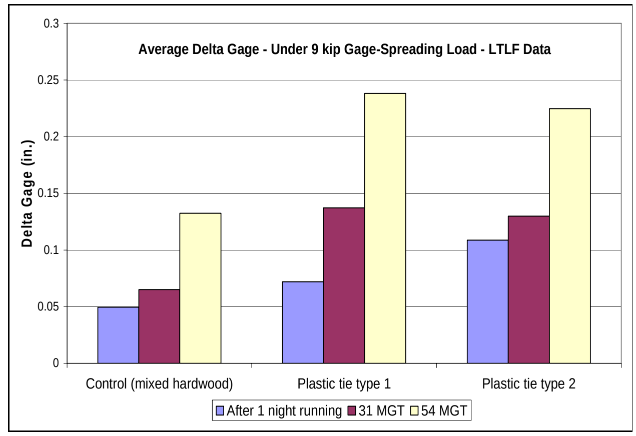


**Figure 3. Gage Strength Test Results Obtained during the First 54 MGT in Service**

## Track Gage Strength

The change in gage (delta) under static load was measured to quantify track gage strength. A lateral track-loading fixture (LTLF) was used to apply a 9-kip gage-spreading load at six locations throughout each test sub-zone while the resulting railhead displacements were measured. Higher delta gage measurements (the sum of the high and low railhead displacements) indicate weaker track gage. Note that FRA's GRMS (T18) was also used for gage strength inspections and the test results will be reported for the final assessment of plastic tie performance.

Figure 3 illustrates the average delta gage widening at each of the three measurement cycles taken. The graph shows that resistance to the applied gage-spreading loads is higher in the wood-tie sub-zone than in the plastic tie sub-zones.

Although the average delta gage of the two plastic-tie sub-zones at 54 MGT is about 0.23 inch, the delta gage (gage widening ) measured for type 2 at FAST at 52 MGT was slightly higher at about 0.28 inch. Both tests in revenue service and at FAST experienced similar increases in delta gage within the first 50 MGT (as Figure 3 shows). The degradation rate at FAST, however, reached a steady state and did not increase significantly after the 52-MGT measurement. All subsequent delta gage measurements in the test zone at FAST during more than 620 MGT have remained between 0.2 and 0.3 inch, similar to the hardwood test zone. The steady state of gage strength at FAST was also confirmed using TTCI's Track Loading Vehicle.

Therefore, additional measurements at the NS Mega Site are needed to determine if a similar steady state in delta gage will occur after the initial increase seen during the first 50 MGT.

## Dynamic (under train) Lateral Rail Displacement

The railhead and rail base deflections resulting from the dynamic forces of passing HAL trains were measured using linear voltage differential transducers (LVDTs). A pair of railhead and rail base LVDTs was installed on the high rail and another pair on the low rail directly across from each other at one location in each of the three sub-zones. Figure 4 shows that the dynamic railhead displacement measured on the high rail in the wood-tie control zone was significantly lower (less than 1/2) than those measured in the plastic-tie test zones. These dynamic response results are essentially consistent with gage strength test results. That is, the plastic ties exhibited lateral rail head displacements that were almost 2 times higher than the wood ties due to the lower gage strength of the plastic ties.

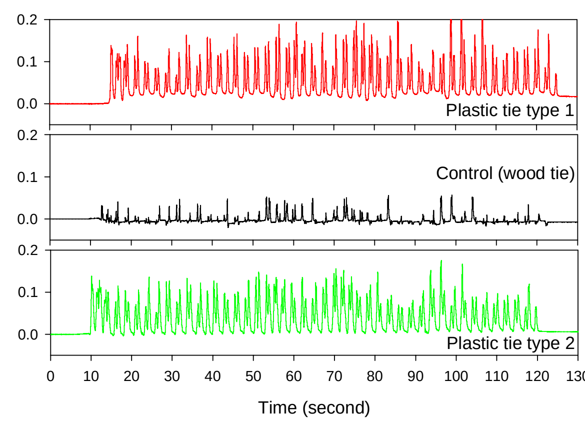


**Figure 4. Dynamic Lateral Railhead Displacement Measured on High Rail**

## Effect of Temperature

The effect of temperature on the plastic tie dimensions, particularly track gage, was a concern since the first prototypes were installed at FAST. To quantify the effect, the unloaded track gage was measured at FAST at about 50 MGT intervals using a track gage device accurate to 1/32 inch. As each gage measurement was taken, the rail temperature was also recorded. After more than 620 MGT, the effect of temperature on track gage has been minimal. Over the 84°F rail temperature range between 14°F and 98°F, the unloaded track gage varied about 0.28 inch.

At the NS Mega Site, the unloaded track gage was measured up to 5 times per month using a steel tape while the local ambient temperature was recorded (see Figure 5). Over the 54°F ambient-temperature range between 27°F and 81°F, the maximum change in unloaded track gage measured in plastic type 1 was less than 0.5 inch. The maximum change in gage measured for type 2 was about 0.24 inch. As expected, the wood-tie control zone experienced the least (0.16 inch) change in gage.

## ACKNOWLEDGEMENTS

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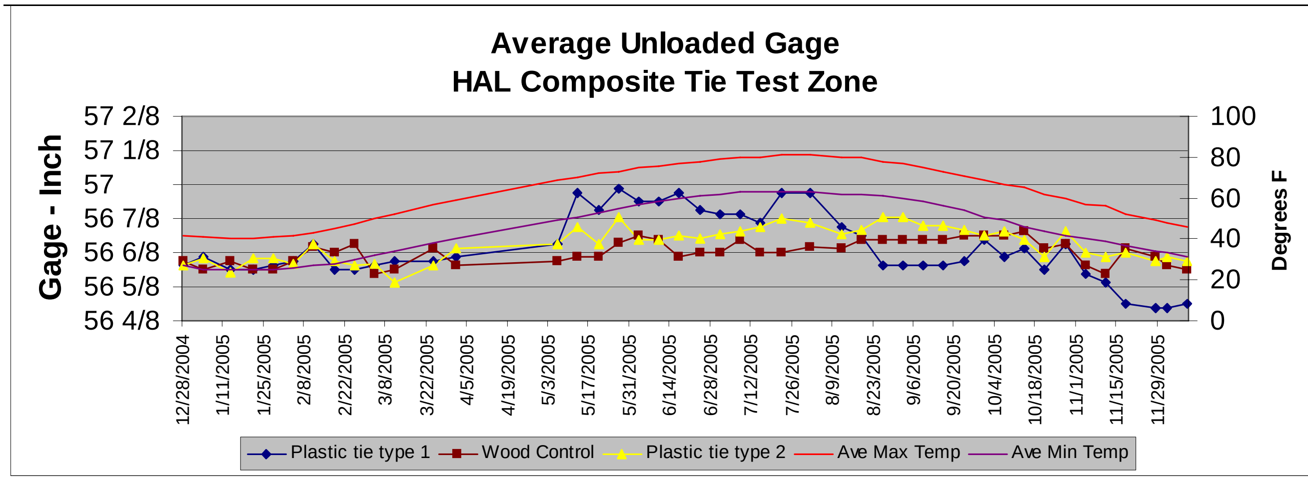


**Figure 5. Effect of Temperature on Track Gage**