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PERFORMANCE OF PLASTIC COMPOSITE TIES IN REVENUE SERVICE

SUMMARY

Two types of plastic composite ties were tested on a 6.8-degree curve at the Norfolk Southern (NS) Railway eastern mega site between Narrows and Bluefield, WV. This test, as shown in Figure 1, was part of the Heavy Axle Load (HAL) Revenue Service Test Program funded by the Association of American Railroads and the Federal Railroad Administration (FRA). From November 2004 to May 2010, the test ties were subjected to 282 million gross tons (MGT) of mostly HAL traffic and were capable of supporting HAL traffic with acceptable performance. There were no problems related to track geometry, gage strength, tie plate cutting, cut spike uplift, or fastening system component failure.

In April 2009, after approximately 230 MGT, the entire test curve was regaged because of wide gage in the adjacent wood tie spirals of the same curve. The plastic composite ties did not exceed wide gage limits.

Results from measurements taken with a light track loading fixture and FRA's T-18 gage restraint measurement system test vehicle indicated that although gage strength degradation and gage widening were slightly higher in the plastic composite ties than in the wood ties, the trends were similar to wood ties.

Plastic composite ties tend to have lower bending stiffness and lower toughness, as compared with wood ties. A total of five plastic composite ties from one supplier broke during the test. After 212 MGT, one tie broke near its center at a void in the plastic composite material. Near the end of the test, four more ties broke along the cut spike plane as a result of a wedging force created as the spikes were inserted into hard synthetic tie plugging material.

Pilot holes for cut spikes reduced the occurrence of cracks and plastic composite material buildup between the plate and the top of the plastic composite ties during spike insertion.

Figure 1. Plastic Composite Tie Test Zone at the NS Revenue Service Mega Site

BACKGROUND

Since 1997, Transportation Technology Center, Inc. (TTCI), has been monitoring the in-track performance of plastic composite ties under heavy axle load (HAL) traffic at the Federal Railroad Administration's (FRA) Facility for Accelerated Service Testing (FAST) near Pueblo, CO. Some of the plastic composite ties tested at FAST have been able to withstand 39-ton axle loads. In November 2004, a test was started at the eastern mega site with NS to monitor the performance of composite ties in revenue service HAL operation conditions.

OBJECTIVE

The plastic composite tie test at the Norfolk Southern (NS) mega site was conducted to evaluate performance of these ties on an active HAL route under typical track geometry, train handling, and environmental conditions that exist in revenue service but not at FAST.

METHODS

In November 2004, the plastic composite tie test zone was installed in a 6.8-degree curve between Narrows and Bluefield, WV. It consisted of three adjacent subzones: one 75-tie section of composite ties from one supplier, one 75-tie control section of NS standard solid-sawn mixed hardwood ties, and another 75-tie test section of plastic ties from another supplier.

The test zones were monitored for track geometry and gage strength degradation, using FRA's T-18 test vehicle and light track loading fixture. Ties were also monitored for tie bending, deflection, rail wear, tie cracking, and tie plate cutting.

RESULTS

In November 2004, new ties were installed, and at the suppliers' recommendation, the cut spikes were driven into the plastic composite ties without first boring pilot holes. Cracking in the rail seat area occurred in 4 percent (32 of 750) of the spike locations of plastic composite ties manufactured by one supplier and in less than 1 percent (6 of 750) of the plastic ties manufactured by another supplier.

In April 2005, after approximately 30 million gross tons (MGT), as a precautionary measure, nine ties with cracks were replaced, and replacement ties were driven into pilot holes, resulting in no cracking during installation and a reduction in material buildup around the spike holes between the plates and tops of ties. The cracks that remained in track did not grow significantly during the remainder of their time in service. The cut spike holding power of the plastic material was not affected by the cracks. In fact, maintenance because of cut spike uplift was not required in either of the plastic tie test zones during the period of performance.

In October 2009, measurements were taken to compare the bending behavior of the plastic composite test ties with the wood control ties under dynamic train loads. Figure 2 shows the measured maximum downward and upward displacement results.

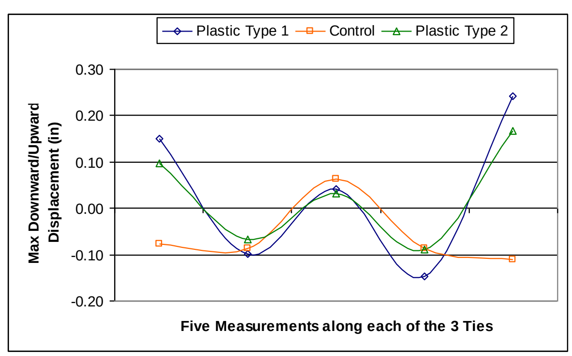

Figure 2. Vertical Deformation Behavior of Plastic Ties Composite and Wood Ties

As shown in Figure 2, the ends of the plastic composite ties bent upward much more than the wood ties, which is characteristic of the lower bending stiffness of plastic composite ties as compared with wood ties. Test results may indicate potential long-term problems associated with ballast pumping around the ends of the ties and large bending stress in the tie plates, which have been observed for some plastic composite ties evaluated under the program at FAST.

Railhead profile measurements were taken to determine whether the difference in bending stiffness between the plastic composite ties and the wood ties affected rail wear caused by HAL traffic. The results of four measurements taken during the test indicated that the difference in railhead area loss in the three subzones at the conclusion of the test was less than 0.04 square inch (i.e., no significant difference).

Gage strength degradation is gage widening as a function of applied load and accumulated traffic/ tonnage. For the duration of the test (282 MGT), the plastic composite ties performed in the respect of gage strength. Figure 3 shows gage strength degradation test results using light track loading fixture. The plastic composite ties exhibited slightly higher gage spreading than the wood ties, but they exhibited gage strength degradation trends similar to wood ties.

In April 2009, the entire test curve including the plastic composite test ties was regaged because of wide gage in the adjacent wood tie spirals of the same curve—not because of gage widening of the plastic composite ties. The regaging procedure used for the plastic composite ties was basically the same as that used for the wood ties relative to spike removal, spike-hole filling using a synthetic material, and respiking. Pilot holes for the cut spikes were drilled at the locations nearest the edge of the ties.

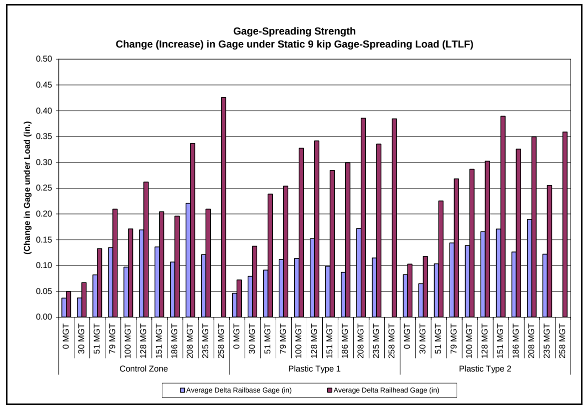

Figure 3. Gage Strength Degradation Test Results

Figure 3 also shows the increased gage strength (reduced gage widening) in the three subzones resulting from regaging (done after 208 MGT but before 235 MGT measurements).

In April 2010, the final track gage measurements were taken in the plastic composite tie and wood tie control test zones using FRA's T-18 GRMS test vehicle. Figure 4 shows the unloaded gage results, which indicate slightly higher but similar gage in the plastic composite tie zones as compared with the wood tie control zone.

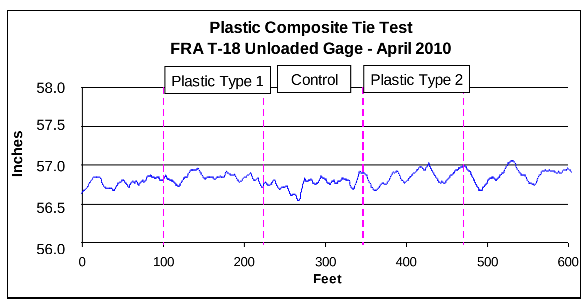

Figure 4. Unloaded Track Gage Test Results of Test Zone

The effect of ambient temperature on the unloaded track gage over a 54°F range (27–81°F) indicate the following maximum changes in gage: 0.24 inch for one type of plastic tie type to 0.5 inch for another plastic tie type, and wood ties 0.16 inch.

In May 2010, when the test was concluded, a total of 5 of the 75 plastic ties from one supplier had completely broken in two. In November 2008, one tie broke at a material void near its center and was replaced. In April 2010, three more ties were found broken during a scheduled NS/TTCI inspection. One month later, as the ties were removed from track, another broken tie was found. These last four ties broke along the transverse, cut spike plane.

Visual inspection indicated that the break initiation appeared to be located at spikes holes nearest the edge of the tie for the four ties that broke in two along the spike plane. The breaks may have occurred as a result of the wedging force of the spikes driven into the synthetic tie plugging material, which was used during the regaging operation.

CONCLUSIONS

The plastic composite ties tested were capable of supporting HAL traffic with acceptable performance. There were no problems related to track geometry, gage strength, tie plate cutting, cut spike uplift, or fastening system component failure in the section of track where the plastic composite ties were installed.

However, plastic composite ties exhibited lower bending stiffness and lower toughness, as compared with wood ties. Cracking and fracture was observed in a small number of plastic composite ties because of spiking without pilot hole, material void, or wedging force of spikes driven into synthetic plugging material.

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*As of January 2008, the technologies formerly licensed to Polywood, Inc., were and are currently licensed to Axion International.

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