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Wood Ties and Fastening Systems Performance at FAST (1995-2004)

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Summary

In response to railroad requirements for more reliable and longer lasting cross ties and fastening systems for use on heavy axle load (HAL) lines, Transportation Technology Center, Inc. (TTCI), Pueblo, Colorado, continues to evaluate the in-track performance of new components. This Technology Digest reports on the performance of ties and fastening systems tested at the Facility for Accelerated Service Testing (FAST) near Pueblo, Colorado.

Between November 1995 and April 2004 most of the test ties, installed on a 6-degree, 5-inch superelevation curve, were subjected to more than 1,000 million gross tons (MGT) of 39-ton axle load traffic using cars loaded to 315,000 pounds. Significant findings of the test include:

- The effect of the vehicle truck type on load environment and cross tie/fastener performance can be significant. The use of warp stiffened trucks at FAST reduced the 90th percentile lateral loads from 18.0 kips under standard three-piece trucks to 12.5 kips. This resulted in increased gage life (tonnage before regaging) and reduced plate cutting and spike killing. The majority of the tie and fastening system component degradation occurred during the standard three-piece truck operations of Phase V (600 MGT).
- The effects of wood species on tie performance were also significant – especially under three-piece trucks and cut spike fasteners. High density species such as oak had gage lives beyond the 600 MGT of the test. Lower density species such as Southern Yellow Pine (SYP) had gage lives of 200 MGT under three-piece trucks. Under warp stiffened trucks, the low density species had gage widening lives beyond the 480 MGT of the test.
- The effect of fastening system was also significant for the three-piece truck load environment and lower density species. For high density species, the effect of fastener on gage life was undetermined. Both cut spikes and elastic fasteners provided a gage life longer than the test duration. For most low density species, elastic fasteners increased gage life from 200 MGT to beyond 600 MGT. Elastic fasteners also provided significantly higher gage-spreading strength in both the high and lower density species than cut spikes.
- Improvements in elastic fastener plate and plate fastener screw spike durability are needed. While the rolled plate and screw spike fastener system tested provided gage life benefits, the components experienced higher failure rates than conventional plates and cut spikes.

The objective of the Crosstie and Fastener Test is to evaluate the in-track performance of ties and fastening systems under 315,000-pound cars and to scan the industry for new and improved components.

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Introduction

In response to railroad requirements for more reliable and longer lasting cross ties and fastening systems for use on heavy axle load (HAL) lines, Transportation Technology Center, Inc. (TTCI), Pueblo, Colorado, continues to evaluate the in-track performance of new components. This Technical Digest reports on the performance of ties and fastening systems in test under 315,000-pound cars at TTCI's Facility for Accelerated Service Testing (FAST) near Pueblo, Colorado.

Between November 1995 and April 2004 most of the test ties, installed on a 6-degree, 5-inch superelevation curve, were subjected to more than 1,000 million gross tons (MGT) of 39-ton axle load traffic using cars loaded to 315,000 pounds.

The test findings suggest there are several ways to reduce the capital intensity and the stress state of the railroad. For cross ties, this can be accomplished by having a product that does not require maintenance before the rail it supports does. For example, to reach a 468 MGT regaging life (the current industry average rail life on a 6-degree curve)[1] under FAST/HAL loading, one can use:

- Any of the tie/fasteners tested and warp stiffened trucks
- Any of the ties tested with elastic fasteners and three-piece trucks
- Any of the high density ties tested with cut spikes and three-piece trucks

Background

The HAL Research Committee (HALRC), whose members include senior officials of the Class I railroads and the FRA, is charged with steering the research and test that is conducted under the FAST/HAL program. The new test components were selected by the HALRC during the Fall of 2003 meeting and were installed in 2004.

Figure 1 is a timeline of the crosstie and fastener test beginning with the installation of new test zones in November 1995. The timeline shows the tonnage accumulated during test Phases III, IV, and V; the cumulative tonnage on the test zones; the median high rail dynamic loading to which the test zones were subjected during each phase; and major maintenance that was performed. Figure 1 also indicates that the test zones still in track after more than 1,000 MGT were removed and replaced with new tie and fastener system components in 2004.

Effect of Dynamic Wheel Load (Truck Type)

The tie and fastener test zones are located in the 6-degree, 5-inch superelevation curve of the High Tonnage Loop (HTL) at FAST. The components are subjected to the load environment resulting from the 39-ton axle load HAL test train, which typically consists of 70 to 80 cars loaded to 315,000 pound gross rail load (GRL). The test zones accumulated about 125 MGT per year.

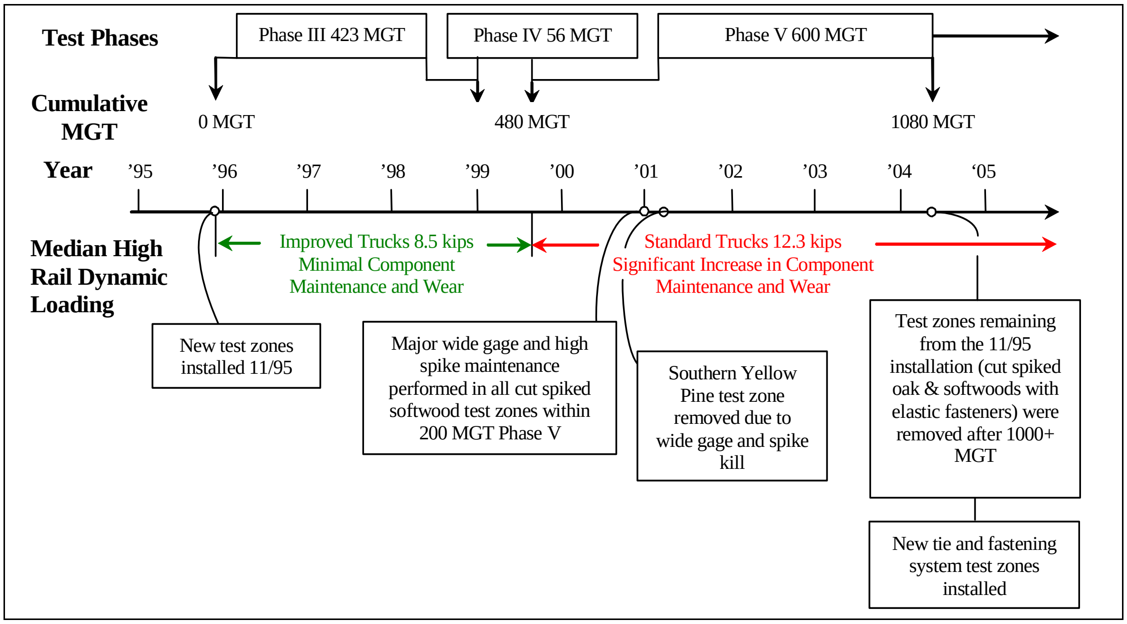

Figure 1. Timeline of the Crosstie and Fastener Test from November 1995 to April 2004

The load environment is monitored using TTCI's wayside load station located in the test curve. Table 1 shows that under the current train configuration using standard suspension trucks, the median and the 90th percentile dynamic lateral loadings on the high rail are about 12.3 kips and 18.0 kips, respectively, at the standard operating speed of 40 mph.

Table 1. Dynamic Lateral Load Environment in the Test Curve from TTCI's Wayside Load Station

	High Rail Lateral Loading (kips)		Percent Increase
	Phase III (Improved Suspension)	Phase V (Standard Suspension)	
Median	8.5	12.3	44.7
90th Percentile	12.5	18.0	44.0

The first 423 MGT that accumulated over the new ties installed in November 1995 occurred during test Phase III of the FAST/HAL test program. During Phase III, the HAL train was equipped with improved suspension trucks that produced the lower lateral loading shown in Table 1.[2]

Phase IV was a short 56 MGT test of the effects of lubrication, primarily on rail wear. The improved suspension trucks remained under the train during the brief evaluation of Phase IV.

The HAL train was refitted with standard suspension trucks after the test zones installed in 1995 had accumulated about 480 MGT; that marked the beginning of Test Phase V.

Table 1 shows that the median lateral loading on the high rail during Phase V was almost 45 percent higher than during Phase III. As a result of the more severe load conditions, gage widening, spike kill, tie plate cutting, and fastening system component problems increased significantly during this test phase.

While test zone maintenance and component wear was minimal during the less severe loading of Phase III, Figure 1 shows that major maintenance was required during Phase V.

The tie and fastening system wear and degradation conditions reported here are mostly from the more severe load environment of standard truck operations.

Effect of Tie Type (Wood Species)

The effect of wood species on tie performance was significant. Figure 2 shows the gage widening life of all the cut spiked softwood tie test zones exceeded 480 MGT under improved suspension truck operations. Under standard trucks the same softwood tie test zones required regaging after 200 MGT. The gage widening life of the oak tie test zone under the same conditions, however, extended beyond 600 MGT.

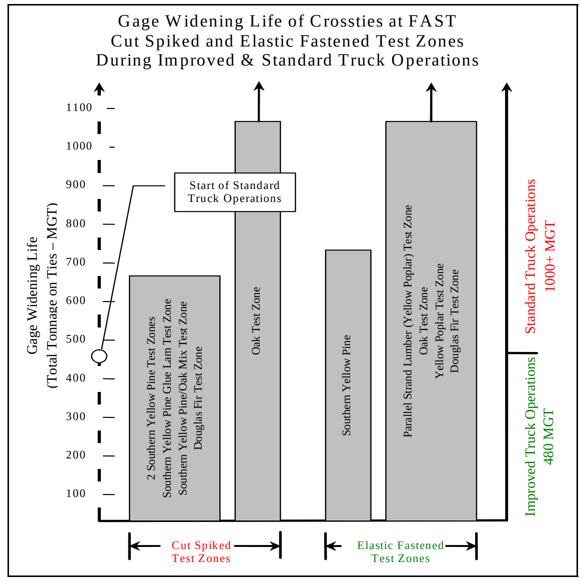

Figure 2. Gage Widening Life of Crossties at FAST

When the ties were removed from track at the end of the 600 MGT Phase V test, they were inspected and measured for tie plate cutting and plate area compression. Although one of the Douglas fir test zones had accumulated about 70 MGT more than the other test zones, Figure 3 indicates the oak ties provided at least 50 percent better resistance to plate cutting and plate area compression than the Douglas fir ties.

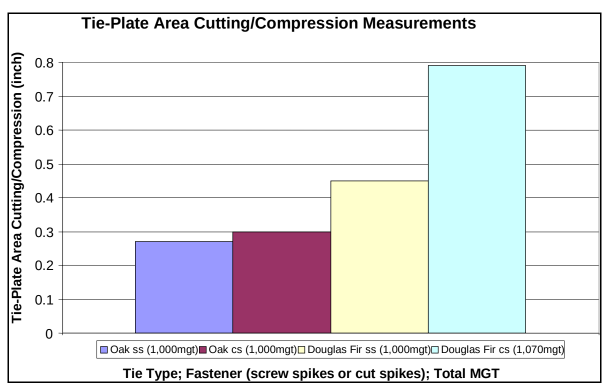

Figure 3. Tie-Plate Area Cutting/Compression Measurements

Effect of Fastener Type

In the cut spiked and the elastic fastened Oak tie test zones the effect of fastener on gage widening was undetermined. Neither test zone required gage widening maintenance over the duration of the test (600 MGT Phase V; >1,000 MGT total). The type of fastener did, however, have an effect on the performance of the softwood tie test zones. Figure 2 shows all the cut spiked softwood ties required regaging after 200 MGT of Phase V traffic. By comparison, the elastic fastening system tested extended the gage widening life of a SYP test zone about 320 MGT beyond the 200 MGT life of the cut spiked softwood ties. The gage widening life of the elastic fastened Yellow Poplar, Douglas Fir, and the parallel strand lumber Yellow Poplar test zones was beyond the 600 MGT Phase V duration of the test.

An additional benefit of elastic fasteners over cut spikes was a significant increase in the gage-spreading strength, as indicated by lower delta gage (difference between loaded and unloaded gage). Figure 4 shows a comparison of the delta gage measurements taken periodically in a cut spiked Douglas fir test zone with those taken in four elastic fastened zones including Douglas fir.

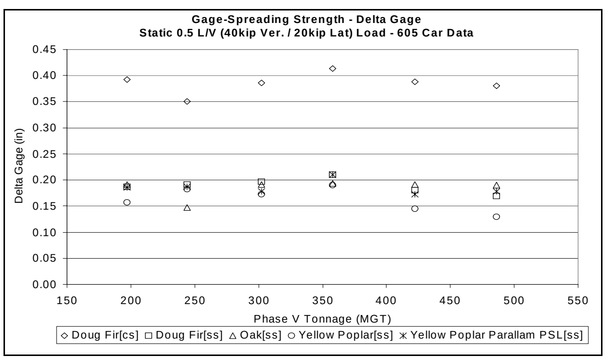

Figure 4. Gage-Spreading Strength (delta gage). Comparing Douglas Fir Ties with Cut Spikes to Ties with Elastic Fasteners and Screw Spikes

Although generally the elastic fasteners at FAST provided increased gage life, higher gage strength, and less tie plate cutting under HAL traffic, improvements in tie plate and plate fastener screw spike durability are needed. In the SYP test zone, 16 percent of the 200 tie plates had two or more fractured screw spikes after 600 MGT of Phase V HAL traffic. Fractured cut spikes were not a major problem on the HTL.

During 500 MGT of Phase V traffic, almost 9 percent of the 1,096 16-inch rolled-steel plates in the elastic fastener test zones had fractured along the raised shoulders. During the same period, less than 1 percent of the 1,600 14-inch cut spike tie plates were reported fractured.

New test zones installed in 2004 will be used to evaluate two types of elastic fastener tie plates and high strength screw spikes in an effort to identify components that will withstand HAL traffic.

Acknowledgements

TTCI acknowledges and appreciates the members of the Railway Tie Association (RTA) for its continued support of the Crosstie and Fastener Test at FAST. Their members donated the majority of the ties that were installed in 1995. The performance results of those ties were summarized in this Technical Digest. Complete test details will be published in TTCI Research Summary RS-05-009.[3]

Fastening system suppliers also continue to support the test program. Components for this test were donated by: AirBoss Railway Products, Inc., Pandrol® USA, and Lewis Bolt & Nut Company.

We also thank our primary customers, the Association of American Railroads, and the Federal Railroad Administration for their loyal support of the FAST/HAL program; and the individuals from the Class I roads who serve on the Technical Advisory Group and on the Heavy Axle Load Research Committee.

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