TTCI TECHNOLOGY DIGEST

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The research described was performed by Transportation Technology Center, Inc., a wholly owned subsidiary of the Association of American Railroads.

Update: Wood Tie Fastening System Study

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Key Findings:

- The primary failure mode was broken spikes found in the test zone with elastic fastener plates installed. Out of 300 spikes, 39 broke on the high rail within 300 million gross tons (MGT).
- Plate cutting was minimal across all nine test sections.
- Gage strength tests using TTCI's Track Loading Vehicle (TLV) showed that the gage widening of each test zone was within the typical range of wood tie tracks.
- Unloaded track gage in test zones showed little change through 279 MGT.

Transportation Technology Center, Inc. (TTCI) continues to evaluate the in-track performance of wood tie fastening systems on the High Tonnage Loop (HTL) at the Facility for Accelerated Service Testing (FAST). In August 2017, 760 new mixed hardwood ties equipped with nine different fastening systems were installed and tested on a 6-degree, 5-inch superelevation curve on the HTL. Tie plates, hold downs, and fasteners were the main variables in this test. The test ties and fastening systems were subjected to more than 500 MGT of 39-ton axle load traffic using cars loaded to 315,000 pounds (less than 10 percent of the cars were loaded to 286,000 pounds). Cut spike breakage on one type of elastic fastener plate was the primary failure mode found thus far on these test zones.

With the recommendations of the Tie and Fastener Technical Advisory Group (TAG), several remediation methods will be evaluated on the FAST HTL in the summer of 2020 to determine the effectiveness of reducing broken spikes. FAST is located at the Federal Railroad Administration's (FRA) Transportation Technology Center (TTC) near Pueblo, CO. This work is part of the Association of American Railroads' Strategic Research Initiative on Improved Tie and Fastener System Performance.

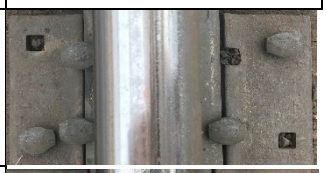
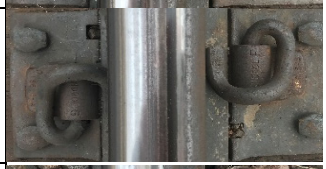
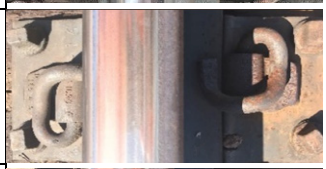
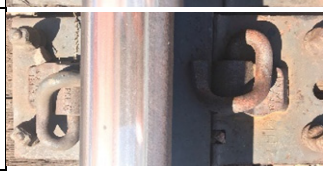
TEST ZONE SETUP

The test zones were set up in Section 25 of the HTL. The FAST train was operated at 40 mph with approximately 2 inches of overbalance speed for the test curve, which helped to accelerate component wear especially on the high rail. Track geometry at FAST is maintained to FRA Class 4 track safety standards. Heavy axle load tonnage is accumulated on the test zones through a consist of 315,000-pound (39-ton axle load) cars. The annual tonnage on the HTL averages 130 MGT.

Table 1 summarizes the setup of the nine test zones; photos in the table show tie plate types and spiking pattern for each zone. New ballast was used for all nine test zones. The variety of the fastening systems selected for the test was recommended by the Tie and Fastener TAG. As of October 16, 2020, the ties had accumulated over 500 MGT. With the exception of those zones

outfitted with elastic fastener plates, rail anchors were installed for all zones using American Railway Engineering and Maintenance-of-Way (AREMA) approved 14-, 16-, and 18-inch plates.

Table 1. Summary of nine wood tie test zones

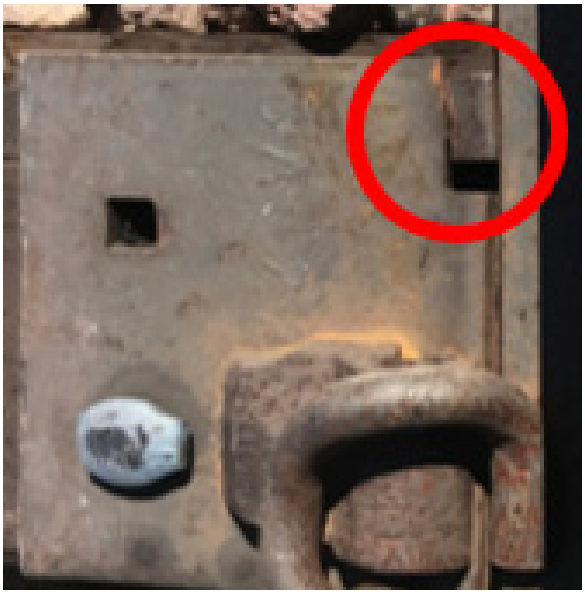
Test Zone	No. of Ties	Fastening Information	Photos
1	100	14″ AREMA plate with five cut spikes + rail anchors	
2	100	16″ AREMA plate with five cut spikes + rail anchors	
3	100	18″ AREMA plate with five cut spikes + rail anchors	
4	100	16″ elastic clip plate with four cut spikes	
5	100	18″ elastic clip plate with three cut spikes	
6	75	18″ elastic clip plate with four screw spikes	
7	75	16″ elastic clip plate with four drive spikes	
8	36	16″ elastic clip plate with four screw spikes	
9	74	18″ elastic clip plate with four drive spikes	

VISUAL INSPECTION

Visual inspection identified broken spikes on plates with elastic fasteners (Zone 5) as the main failure mode for the nine test zones. While some other failures and issues were observed, none were recurring or prevalent enough to be considered major. The findings of the inspection include:

- Zone 5: 39 broken high rail spikes out of 300 installed.
- Zone 4: One broken high rail spike.
- Zone 1 (Figure 1a) and Zone 5 (Figure 1b): broken tie plates.
- Plate cutting was minimal through all nine test zones, and there was no meaningful difference between the zones with the tonnage tested.

(a)



(b)

Figure 1. Broken tie plates

BROKEN SPIKES ON TIE PLATES FOR ELASTIC FASTENERS

On April 16, 2019, after 230 MGT, 12 broken spikes were found on the high rail side in Zone 5. Once identified, these were removed and replaced. On September 18, 2019, after 284 MGT, 27 broken spikes were found on the high rail side in Zone 5; however, the new spikes installed on April 16 remained intact and were not in this group. The broken spikes identified in this second inspection were replaced by driving new spikes through the original spike holes (Figure 2). Broken spikes were usually found in elongated spike holes.

Figure 2. Broken spikes on 18-inch elastic fastener plates (Zone 5)

Abrasion marks on rails made by the elastic clips were found (Figure 3), indicating slippage between fastener and rail and suggesting that the spikes may have experienced high longitudinal forces in Zone 5.

As a result of this test and TAG recommendations, several remediation methods for the broken spike issue were implemented in the summer of 2020, including:

- Installing rail anchors in Zone 5 and Zone 6 and monitoring their performance.
- Installing 50 wood ties with curve block plates.
- Monitoring the performance of drive/screw spikes on elastic fastener plates.

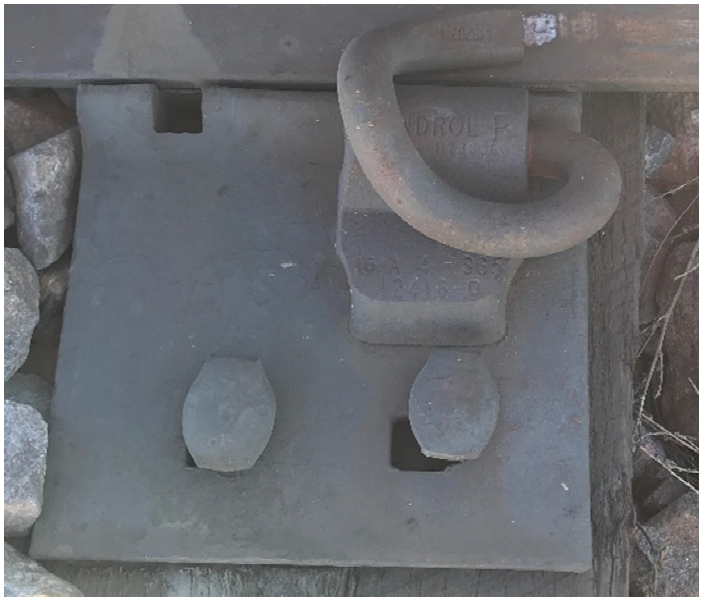


Figure 3. Elongated spike holes and abrasion mark on rail

Once the longevity of different spike types on elastic fasteners is known, a life cycle cost analysis can be conducted to find the fastening system that is most beneficial for railroads.

TRACK GAGE MEASUREMENTS

Gage strength—a direct indicator of how well a tie and fastener system performs—is the resistance of the gage of the track to widening under an applied load. To assess for gage strength, TTCI's TLV ran through all nine test zones on September 17, 2018. Specifically, the TLV ran with 124 MGT at 18 mph on both a loaded and unloaded track gage of each test zone, and applied a 33-kip vertical force and an 18-kip gage widening force.

The results of this test (Figure 4) showed that the average gage widening from the TLV run was within 0.4 inch, which falls into the typical range for wood tie tracks.[1] Testing also showed that the unloaded track gage for each test zone remained at a similar level through 279 MGT.

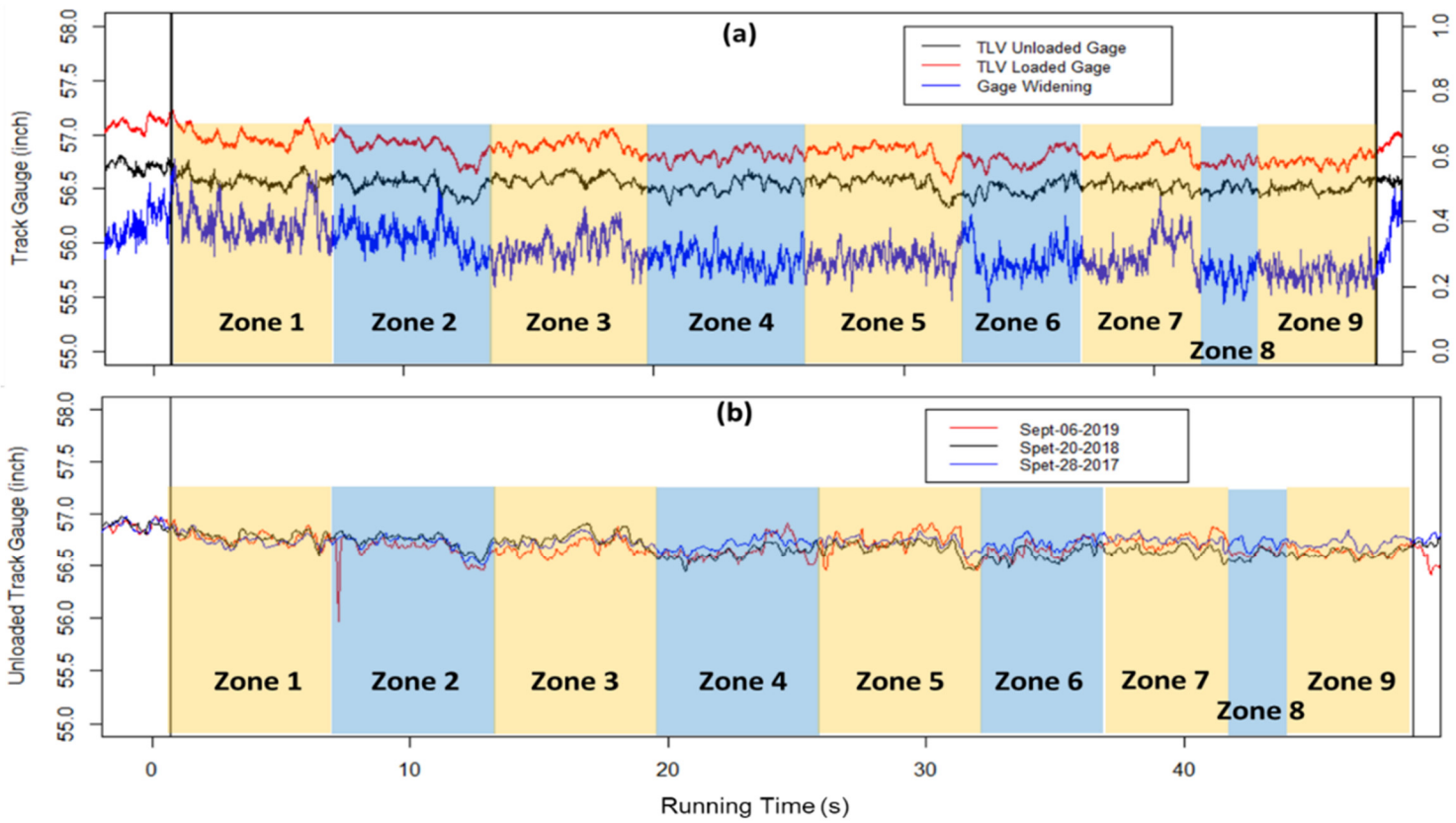


Figure 4. Track gage measurements: (a) TLV at 124 MGT; (b) comparison of unloaded track gage at 0, 124, and 279 MGT

CONCLUSIONS

TTCI's tests on new types of wood ties with various fastening systems showed that plates with elastic clips are the most likely to suffer spike breakage, and elongated spike holes appear to be associated with this failure.

The study also showed that gage widening with these new ties is still within specifications, but there may be issues with abrasion and slippage.

References

1. McHenry, M., and LoPresti, J. (2016). "Field evaluation of sleeper and fastener designs for freight operations. Proceedings of the 2016 World Congress of Railway Research, Milan, Italy.

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