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Performance of Elastic Fasteners on an 8-Degree Curve in Revenue Service

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Summary

A test of elastic rail fastening systems was conducted on an 8-degree curve in the Norfolk Southern (NS) Mega Site as part of the Revenue Service Test Program, which is jointly sponsored by the Association of American Railroads and the Federal Railroad Administration. The two elastic fastener types, from two manufacturers, were subjected to 260 MGT of mostly HAL traffic since their installation in June 2005. In January 2010, NS decided to remove all the elastic fasteners from track, effectively terminating the test.

Conclusions

- The elastic fastening systems tested outperformed the cut spike system based on the gage strength test results:
  - The two sections of wood-tie track fitted with the elastic fastening systems and screw spikes provided 3 times higher gage strength than the track fitted with the NS-standard cut spike system.
  - The elastic fastener test zones did not use additional gage restraint hardware; however, two gage rods were installed in the cut spike control zone in May 2009.
- The lateral rail restraint measured in the elastic fastener zones was over 3 times higher than in the cut spike control zone.
- The lateral deflection on the low rail measured throughout the cut spike control zone, under heavy axle load cars operating at track-speed, was almost twice that measured on the same rail in the elastic fastening system zones.
- Eleven, out of the 360 NorFast rail clips, fractured under the rail clip keeper portion of the tie plates. The results of the laboratory test on NorFast rail clip samples from the installations at the Facility for Accelerated Service Testing and the mega site showed that these fractures were incidental and removal was not necessary.
- Cut spike uplift of more than 1 inch occurred in almost 4 percent of the spikes in the cut spike control zone (5 spikes per tie plate). In the elastic fastener zones (4 screw spikes per tie plate), none of the Lewis Bolt & Nut screw spikes significantly uplifted nor fractured during the test.
- The cleats, designed for gage restraint on the bottom of the NorFast plates, prevented the plates from seating into the ties during the installation. When the plates seated after some traffic, a small gap developed between the bottom of the screw spike head and the top of the plate. The gaps did not increase during the test. The lateral track loading fixture test, which applies the gage spreading load at the neutral axis of the rail, indicates the cleats may provide some increased resistance to lateral tie plate translation.
- There were no major differences in rail wear attributed to the different types of fastening systems tested.

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INTRODUCTION

The elastic fastener test was installed in June 2005 near Roanoke, Virginia.[1] The objective was to compare the performance of two types of elastic fastening systems with that of the NS-standard cut spike system under heavy axle load (HAL) traffic on an 8-degree curve in revenue service. Both of the elastic fastener types — AirBoss and NorFast — had been successfully subjected to HAL traffic on the High Tonnage Loop at the Facility for Accelerated Service Testing (FAST), Pueblo, Colorado.

Test Zone Installation

The test zone was installed in the body of an 8-degree curve at mile post V238.5 just outside of Roanoke, Virginia. It consisted of three subzones: (1) 100 consecutive ties with AirBoss 16-inch tie plates and rail clips, (2) 90 ties with Norfast 16-inch tie plates and rail clips: 82 of the 90 ties with Norfast were consecutive and at each of the two approach transitions 4 were intermixed with Pandrol 16-inch tie plates and rail clips, and (3) 90 consecutive ties with NS-standard 18-inch tie plates and cut spikes (control zone). All the plates were installed on existing ties.

The AirBoss and NorFast tie plates were fastened to the ties using 15/16-inch-wide by 6-1/2-inch-long Lewis Bolt & Nut high strength screw spikes in 11/16-inch-diameter by 6-inch-deep pilot holes. The NS-standard tie plates were fastened to the ties using standard cut spikes and no pilot holes. The NorFast rail clips were installed using a NorFast on-track, push-along type, hydraulic clip inserter. The same machine was used, after some modification, to install the AirBoss rail clips. A typical gang spike was used to drive the cut spikes in the NS-standard system zone.

NorFast recommended that no abrupt changes, from track that is fitted with the NorFast system to track fitted with a cut spike system, be created in a curve. However, this change is acceptable in tangent track. Because the test was to be located in the body of the curve, NorFast suggested the creation of transition sections at both approaches of the test zone. The installation approved by NorFast consisted of intermixing five 16-inch rolled Pandrol steel tie plates and e-clips with the first four NorFast ties in the approaches. The NorFast test zone, therefore, consisted of 8 intermixed NorFast-fitted ties at the ends with 82 consecutive NorFast-fitted ties in the center.

While the AirBoss and the NS-standard plates had a flat bottom, the bottom of the NorFast plates had cleats designed to provide increased resistance to gage widening (see Figure 1).

Adzing of the ties was not required in the AirBoss or the NorFast zones because the 16-inch tie plates fit within the footprint of the 18-inch NS-standard plates they replaced. Track workers used a router in the control zone to trim some of the tie-plate cutting marks where the 18-inch NS-standard plates were reinstalled. The entire test zone was gaged to 56½ inches, and the old spike holes were filled with synthetic tie plugging material.

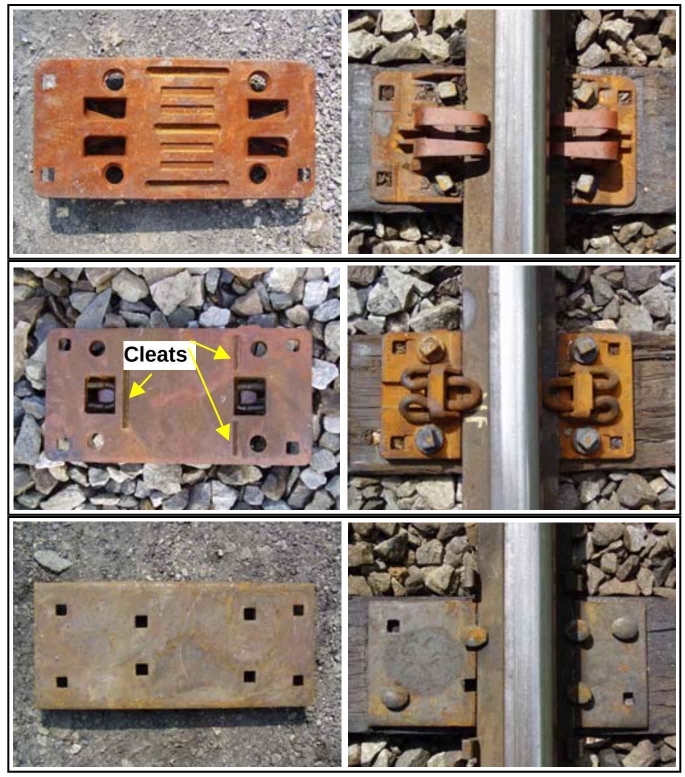

Figure 1. Views of the 16-inch AirBoss (top), 16-inch NorFast Systems (both with Lewis Bolt & Nut high strength screw spikes), and 18-inch NS Standard plate and cut spike system (bottom)

Track Gage Strength

Figure 2 shows the gage strength degradation test results for the three zones using a lateral track loading fixture (LTLF). After 250 MGT, the gage strength of the two elastic fastener test zones was more than 3 times stronger (less gage widening) than that of the control zone with the NS-standard 18-inch plate and cut spike system. The LTLF test, which applies the gage spreading load at the neutral axis of the rail, indicates the cleats may provide some increased resistance to lateral tie plate translation.

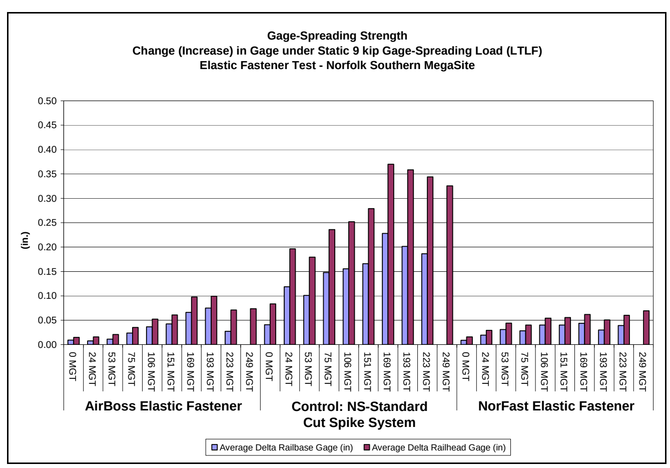

Figure 2. Gage Strength Degradation Data showing the Significant Benefit of the Elastic Fasteners Tested over the Standard Cut Spike System

Figure 3 shows a sequence of in-motion, unloaded track gage measurements taken in the elastic fastener and the cut spiked test zones using the Federal Railroad Administration's T-18 GRMS test vehicle. Measurements on the graph indicate that portions of the control zone reached 57 inches, 1/2 inch over standard track gage before the track was fitted with elastic fasteners. Two gage rods were installed in the cut spiked control zone prior to the May 2009 inspection when the test zone had accumulated 223 MGT. The test zones fitted with elastic fasteners did not require gage widening maintenance or installation of additional gage restraint hardware.

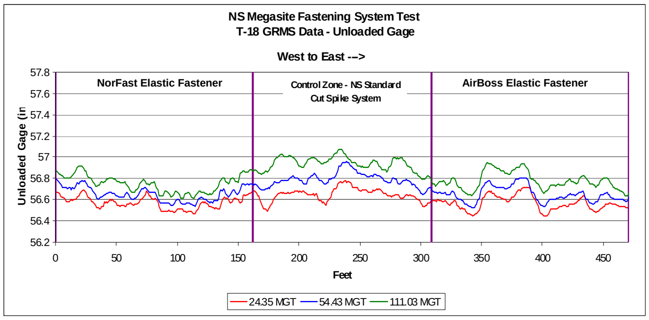

Figure 3. Sequence of In-Motion, Unloaded Track Gage Measurements (Note: Gage in parts of the control zone with the cut spiked track widened ½ inch over nominal gage before the track with elastic fasteners.)

Static Lateral Rail Restraint Test

The Static Lateral Rail Restraint Test was performed early in the test (55 MGT) to quantify the resistance that each fastening system provides. The test setup consisted of a load cell equipped hydraulic cylinder used to apply the 10,000-pound gage-spreading load. The load was applied 5/8 inch below the top of the rail on the gage face. Displacement transducers were used to measure the resulting lateral high rail and low rail head displacement relative to the tie plate. Six locations were measured in each test subzone and five gage-spreading (loading and unloading) cycles were performed at each location. The data acquisition system captured the force and displacement measurements. The results are shown as the average force required to laterally displace the railhead 0.02, 0.03, and 0.04 inch.

Figure 4 shows the lateral rail restraint that each of the systems provided. Data indicates the force required to deflect the high railhead 0.02 inch in the gage-spreading mode was about three times higher (stronger) in the track fitted with the NorFast elastic fastener than the track fitted with the cut spike system. In the AirBoss elastic fastener track, the 6.2-kip force required to deflect the railhead 0.02 inch was about six times higher (stronger) than that required in the cut-spiked track. To deflect the railhead 0.04 inch in the elastic fastener zones, the NorFast elastic fastener provided about three times more resistance and the AirBoss elastic fastener provided about four times more resistance than the cut-spiked track.

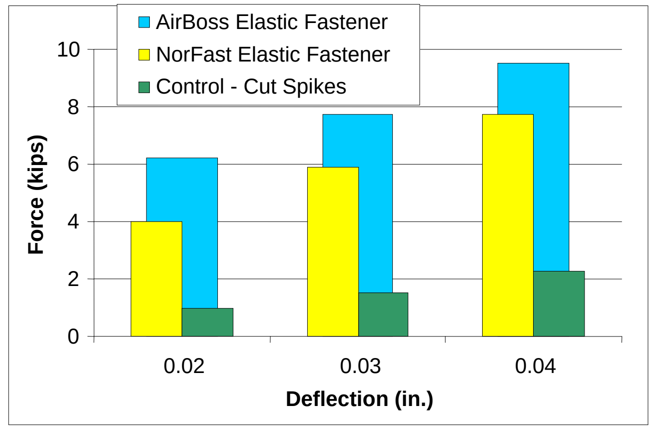

Figure 4. Results of Static Lateral Rail Restraint Test conducted at 55 MGT

Lateral Railhead Deflection under HAL Cars

Lateral railhead deflections resulting from the dynamic loading introduced by passing HAL coal cars were measured early in the test. Each of the subzones was fitted with a pair of transducers to capture the high and low railhead deflections.

Given that the test zone is exposed to underbalance train operating conditions, higher loading and therefore larger deflections are expected on the low rail. Such was the case in the cut-spiked subzone, where the deflection measured on the low rail was almost twice that measured on the low rail of the elastic fastening system zones. Figure 5 shows that the two elastic fastening systems provided similar resistance to the dynamic gage-spreading forces at both rails where measured deflections ranged between 0.06 and 0.08 inch.[2]

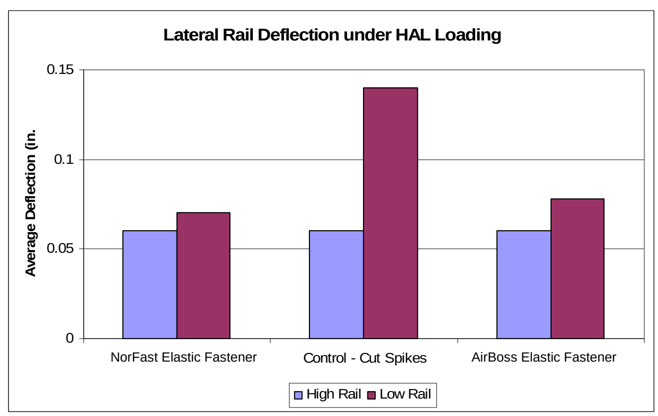

Figure 5. Lateral Railhead Dynamic Deflection under HAL Coal Car Loading

Component Performance and Other Observations

After 70 MGT of service, two of the 360 NorFast rail clips installed were found fractured.[3] The fractures occurred under the rail clip keeper portion of the tie plate, where it was difficult to detect by typical visual inspection, as Figure 6 shows.

Because of similar rail clip breakage (nine of 260), after 455 MGT at FAST, a laboratory study was conducted on samples taken from the two ongoing in-track tests at the eastern mega site and at FAST to determine if this type clip should be removed from service testing. The results of the laboratory study indicated that no such action was necessary.[4] In total, 11 rail clips in the NorFast elastic fastener test zone broke or fell out during the mega site test. Four of the 11 clips broke at a low rail load station installation, where the ties were not properly tamped resulting in severe vertical displacement (pumping) under traffic. The average lateral load on the low rail resulting from traffic was about 20,000 pounds according to load station data. In the AirBoss zone, four rail clips were bent as a result of being struck by track maintenance machinery.

Figure 6. Parts of a NorFast Rail Clips Fractured at 70 MGT

Cut spike uplift of more than 1 inch occurred in almost 4% of the spikes in the control zone where the NS-standard 18-inch plate system (5 spikes per tie plate) was installed. In the elastic fastener zones (4 screw spikes per tie plate) none of the Lewis Bolt & Nut screw spikes significantly uplifted or fractured during the test.

The bottom surface of the NorFast system plates had cleats that were designed to enhance gage-widening restraint. The cleats prevented the plates from seating tightly into the tie during installation. After some traffic, when the cleats were seated into the wood fibers, a gap (about ¼ inch) between the bottom of the screw spike head and the tie plate was created giving the appearance that the screw spikes were uplifting, as Figure 7 shows. Test operators decided not to cinch down the small gap to avoid over tightening and these gaps did not increase throughout the test. The effect of the cleats on the tie surface under the plates was not determined.

Railhead profile measurements were taken to determine if the different types of rail fastening systems affect rail wear with traffic. The results indicate no major difference between the systems tested. Although it had not become a problem, tie plate cutting in the control zone (NS-standard 18-inch pates) was occurring at a higher rate than in either of the test zones with 16-inch plates, where it was minor.

Figure 7. Gap between the Screw Spike Head and Tie Plate after the Tie-Bottom Cleats seated into the Wood Fibers

Acknowledgements

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