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Preliminary Performance of Elastic Fastening Systems in Revenue Service at Eastern Mega Site

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Summary

As part of an Association of American Railroads and Federal Railroad Administration sponsored project, track workers installed the AirBoss and NorFast elastic fastening systems in an 8-degree curve on the Norfolk Southern (NS) eastern mega test site in June 2005. Since then, the fastening systems have been subjected to more than 120 MGT of heavy axle load (HAL) traffic. Preliminary findings and observations are as follows:

- Generally, the two elastic fastening systems and the cut-spike control zone have performed well, as detailed below.
- The gage strength test results have shown that the track fitted with the elastic fastening systems is stronger than the track with the cut-spike system. The data obtained at 111 MGT showed that:
  - – the average loaded gage in the cut-spike subzone was 0.3 inch higher than in the elastic fastener zones,
  - – the peak loaded gage in the cut-spike subzone was higher (57.6 inches) than in the elastic fastener track, where the peak loaded gage was between 57.3 inches 57.2 inches, and
  - – unloaded gage (peak) in the cut-spike subzone was also higher (57.1 inches) than in the elastic system zones (56.9 inches).
- The rail rollover restraint test showed that to roll the railhead 0.04 inch the elastic fastener systems provided much higher rollover restraint than the cut-spiked system. The resistance in the elastic fastener subzones was between 3 (7,800 lb) and 4 (9,600 lb) times higher than that of the cut-spiked subzone (2,000 lb).
- The dynamic lateral railhead deflection measurements taken as HAL trains passed showed the rails with elastic fasteners were displaced 50 percent less than the rails with cut spikes.
- For the AirBoss system, none of the rail clips has fractured or lost toe load, and there have been no tie plate problems.
- For the NorFast system, two of 360 rail clips fractured after 70 MGT. There have been no additional rail clip fractures, and none of the clips has lost toe load. There have been no tie plate problems.
  - – Nine of 260 NorFast rail clips fractured after 410 MGT on the High Tonnage Loop under the FAST Experiment Program.
- Some slight cut-spike and screw spike uplift (about 1/8-inch) has occurred in the three subzones, but none of the high strength screw spikes used with both elastic fastening systems (Lewis Bolt & Nut) has fractured. To date, only slight tie plate cut marks have been observed throughout the test zone.

Transportation Technology Center, Inc. and NS established the eastern mega site in 2004 on a revenue service coal route with predominately HAL traffic to complement testing being performed at the Facility for Accelerated Service Testing.[1] Monitoring of the fastening systems is ongoing to quantify their long-term benefits.

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INTRODUCTION

The objective of the elastic fastening systems test at the eastern mega site is to evaluate the performance of two types of elastic fasteners and to compare them with the performance of NS's standard cut-spike system under HAL traffic. Figure 1 shows the top and bottom views of these systems.

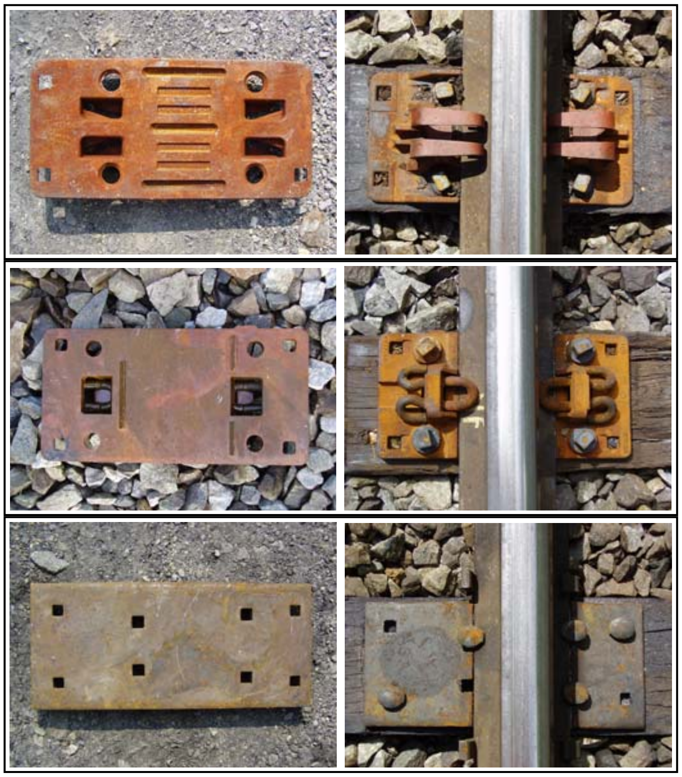

Figure 1. Views of the 16-inch AirBoss (top), 16-inch NorFast Systems (both with Lewis Bolt & Nut high strength screw spikes) (middle), and 18-inch NS Standard Plate and Cut-spike System (bottom)

TEST ZONE INSTALLATION

The test zone was installed in the body of an 8-degree curve at mile post V238.5 of the Virginia division just outside of Roanoke, Virginia. It consists of three subzones: (1) 100 consecutive ties with the AirBoss 16-inch tie plates and rail clip elastic fasteners, (2) 90 ties (82 consecutive and 8 intermixed in two approach transitions) with the NorFast 16-inch tie plates and rail clip elastic fasteners, and (3) 90 consecutive ties with the NS standard 18-inch tie plates and cut spikes (control sub zone).

The 1:40-cant AirBoss and NorFast tie plates were fastened to the existing wood ties using 15/16-in. diameter x 6-1/2-in. long Lewis Bolt & Nut high strength screw spikes in 11/16-in. diameter x 6-in. deep pilot holes. The 1:40-cant NS standard tie plates were fastened to the ties using standard cut spikes without pilot holes. The NorFast rail clips were installed using a NorFast on-track, push-along type, hydraulic clip inserter. The AirBoss clips were installed using the NorFast machine after some minor modification of the clip insertion paddles.. The NS standard cut-spike system was installed using a typical gang spiker

NorFast recommends not to make an abrupt change from track that is fitted with the NorFast system to track fitted with a cut-spike system in a curve. They recommend that such a change be made only on tangent track. Since the test was to be located in the body of the curve, NorFast suggested we create a transition at each approach to their subzone. The two approach transitions that were approved by NorFast consisted of intermixing five Pandrol, 16-inch rolled steel tie plates and e-clips with the first four NorFast ties. The NorFast test subzone, therefore, consists of 82 consecutive NorFast-fitted ties and 8 intermixed Norfast-fitted ties.

Although the tie plates of the three systems differ in material thickness, as Figure 2 shows, all three provide a 1:40 rail cant. While the AirBoss and the NS standard plates have a flat bottom, the bottom of the NorFast plates has cleats designed to provide increased resistance to gage widening (see Figure 1).

Figure 2. Profile View of the Three Fastening System Tie Plates installed: (1) NorFast, (2) NS-Standard, (3) AirBoss

Adzing of the ties was not required in the AirBoss or the NorFast subzones 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 at the ends of the plates. The entire test zone was regaged to 56-1/2 inches, and the old spike holes were filled with SpikeFast ES-50 synthetic tie plugging compound. A tie gang surfaced, aligned, and tamped the test zone for the first time in May 2006 after about 53 MGT.

PRELIMINARY PERFORMANCE

Track Gage Strength

Figure 3 shows the gage widening that has occurred during the period of performance as defined by the unloaded track gage. The first measurement was taken 24 MGT after the test zone was installed and again after 54- and 111 MGT using the Federal Railroad Administration's T-18 gage restraint measuring system (GRMS) car. The data indicates the cut-spike system zone has widened more than the elastic system zones.

Figure 4 shows the differences in the track gage-spreading strength of the three fastening systems as defined by the measured increase in gage resulting from the applied load (loaded gage). The loaded gage measurements were taken with the T-18 GRMS car (under a lateral load 14,000 lb and vertical load 21,000 lb) at 30 mph. The results show higher track gage strength with the elastic fastening systems.

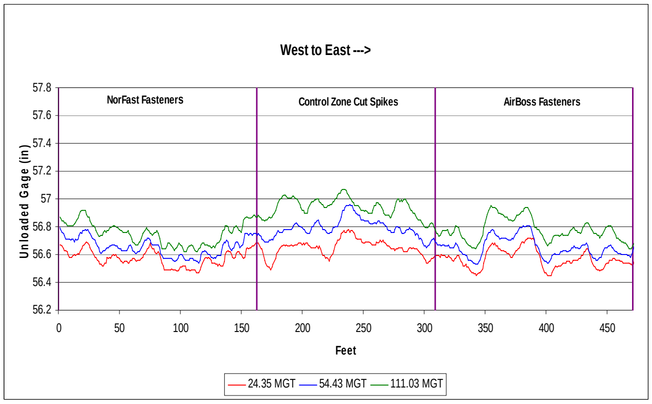

Figure 3. Unloaded Track Gage (T-18 Car)

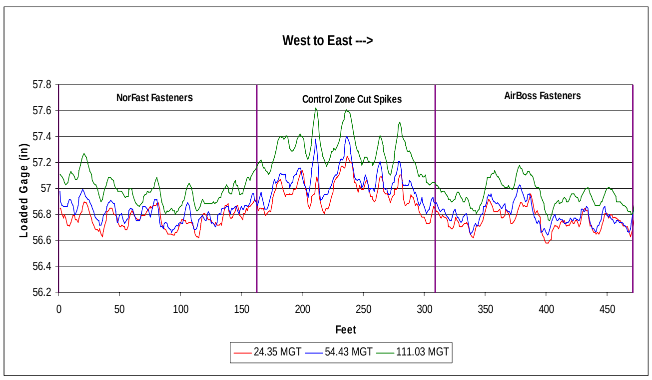

Figure 4. Loaded Track Gage (T-18 Car)

Figure 5 shows the average loaded gage measured in the three subzones. Lower loaded gage values indicate higher gage strength. The loaded gage in the cut-spike subzone was about 0.3 inch more than the two elastic system zones. The peak gage spread in the cut-spike subzone, however, was about 57.6 inch compared to the stronger elastic zones where the peak gage spread was about 57.3 inch in the NorFast subzone and about 57.2 inch in the AirBoss subzone.

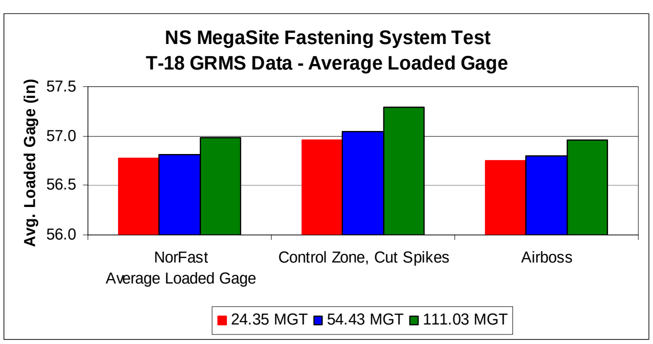

Figure 5. Average Loaded Gage

Rail Rollover Restraint

The Rail Rollover Restraint Test was performed to quantify the resistance that each fastening system provides. The test setup, Figure 6, consists of a load-cell equipped hydraulic cylinder used to apply the 10-kip gage-spreading load. The load is applied 5/8 inch below the top of the rail on the gage face. Displacement transducers were used to measure the resulting lateral high and low railhead 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 displacements. The results are shown as the average force required to displace the railhead laterally 0.02, 0.03, and 0.04 inch.

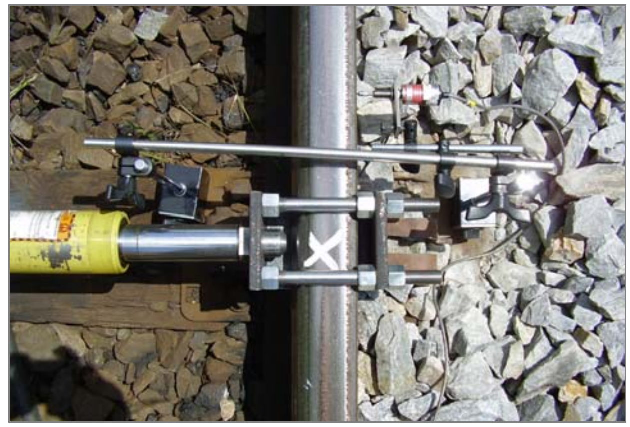

Figure 6. TTCI's Rail Rollover Restraint Fixture

Figure 7 shows the rail rollover restraint that each of the systems provide. Data indicates the force required to roll the high railhead 0.02 inch in the gage-spreading mode was about three times higher in the NorFast subzone than in the cut-spike subzone. In the AirBoss subzone the 6.2-kip force required to roll the railhead 0.02 inch was about six times higher than in the cut-spike subzone. To roll the railhead 0.04 inch, the NorFast subzone provided about three times more resistance, and the AirBoss provided about four times more resistance than the cut-spike subzone.

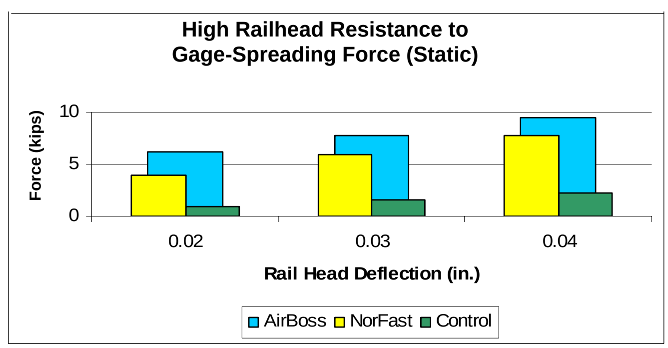

Figure 7. Results of Rail Rollover Restraint Test

Lateral Railhead Deflection under HAL Cars

Lateral railhead deflections resulting from the dynamic loading introduced by passing HAL coal cars were measured after 1.7 MGT. 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 same rail in the elastic fastening system zones. Figure 8 shows that the two elastic fastening systems provided similar resistance to the dynamic gage-spreading forces at both rails, where the deflections measured were between 0.06 and 0.08 inch.

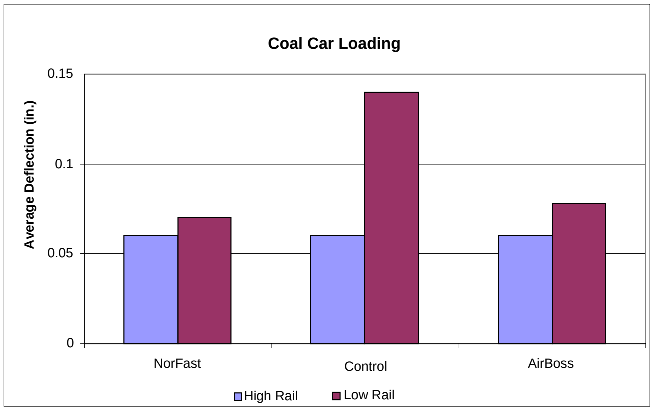

Figure 8. Lateral Railhead Dynamic Deflection under HAL Coal Car Loading

MAINTENANCE RECORDS AND OTHER OBSERVATIONS

On July 20, 2006, after 63 MGT, 11 of the AirBoss rail clips were found bent, presumably by track maintenance equipment and not by wear or failure. Although the rail clips were still in place and none had fractured, all 11 were replaced with new clips. There have been no rail clip or tie plate failures in the AirBoss test subzone.

On September 5, 2006, after 70 MGT, 2 of 360 NorFast rail clips were found fractured (see Figure 9). The fractures occurred under the rail clip keeper portion of the cast steel tie plate where it was difficult to detect by typical visual inspection. There have been no additional rail clip failures and no problems have been reported with the tie plates.

Figure 9. Parts of NorFast Rail Clips Fractured at 70 MGT

Broken clips have also been observed on the High Tonnage Loop under the FAST Experiment Program. Nine of the 260 NorFast rail clips installed in the 6-degree curve at FAST fractured during 410 MGT of 315,000-pound car traffic.[2]

Qualitative observation indicates some tie plate cutting is beginning to develop in the three subzones at the NS mega site. Measurable differences in tie plate cutting that may develop between the fastening systems will be quantified after significantly more cutting occurs. Although there has been some slight screw spike and cut-spike uplift, no maintenance has been required. None of the Lewis Bolt & Nut Co. high strength screw spikes has fractured.

FUTURE WORK

TTCI and NS will continue to monitor the fastening system test to determine the long-term performance characteristics as defined by gage widening, gage strength degradation, required maintenance, and the wear and failure mode of the individual components.

As a result of the two NorFast rail clip fractures, NS conducted a preliminary metallurgical evaluation of the two broken rail clips. TTCI is following up with a detailed laboratory study, which includes a bend test designed to evaluate the fracture characteristics of the clips as well as metallographic and fractographic analyses.

TTCI will also evaluate a sampling of new, used, and fractured clips from FAST as part of the laboratory study.

ACKNOWLEDGEMENTS

The AAR and FRA jointly funded the Mega Site Research Program. ENSCO conducted the GRMS tests. TTCI thanks Leonard Allen and Sung Lee of FRA for their support to the testing program. Appreciation also goes to Norfolk Southern for allowing the test to be conducted on its line and for the cooperation of the test and research department and the support of the track department. AirBoss Railway Products, Inc., Lewis Bolt & Nut Company, and NorFast, Inc. donated the components used for this test. Their continued support of the HAL revenue service test and the HAL test at FAST is greatly appreciated.

REFERENCES

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