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Performance of Rail Fastening Systems on an Open-Deck Bridge

SUMMARY

Transportation Technology Center, Inc. (TTCI) monitored the performance of rail fasteners on an open-deck bridge and its approaches, located at Norfolk Southern Corporation's (NS) eastern mega site (Figure 1). The project was co-sponsored by the Federal Railroad Administration (FRA) and the Association of American Railroads (AAR).

The three rail fastening test systems were (1) Pandrol 16-inch cast plate with screw spikes cut spikes and e-clips, (2) Vossloh 16-inch rolled plate with screw spikes and rail clips, and (3) Pandrol 18-inch Victor rolled plate with cut spikes and e-clips.

A modified version of the lateral track loading fixture (LTLF) was used to measure the gage widening strength of the tie and fastener system.

System 3 widened 2.4 times more at the railhead and three times more at the rail base than System 1 under the 6-kip LTLF gage spreading load in test zones on the bridge. System 3 on the bridge also had the highest loaded gage widening as measured by FRA's DOTX-218 test vehicle. Maximum gage widening was still 0.2 inch after 230 million gross tons (MGT) of traffic.

Due to a rail change, one test zone became a hybrid, which allowed the team to evaluate the performance of System 2 (on low rail) and System 3 (on high rail). The railhead displacement measured on the high rail (System 3) was 4.6 times higher than on the low rail (System 2), where the rail lateral stiffness (Δforce/Δdisplacement) was 3.5 times higher for System 2.

The 2014 results also indicated almost twice higher rail lateral stiffness in System 1 than in System 3 on the bridge for both the high and low rails.

Bridge zones have under-plate rubber pads, whereas approach zones do not. Gage spreading performance between bridge zones and approach zones showed: (a) Comparable performance on the bridge and at the approach for System 1; and (b) better performance at the approach than on the bridge for System 3.

Though rail clip bolts fractured in System 2, no rail clip bolt fractures were reported at FRA's Facility for Accelerated Service Testing (FAST). A System 1 tie plate experienced a structural crack similar to the failure mode seen at FAST.

Figure 1. Track Crew Installing Rail Fasteners on the Test Bridge at NS' Eastern Mega Site

BACKGROUND

The Heavy Axle Load Revenue Service Test Program, which was jointly funded by the AAR and FRA, installed three different rail fastening systems on NS between September 2010 and November 2010 at Wabun, VA.

OBJECTIVE

The test was conducted to document the performance of three fastening systems in a revenue service environment of an open-deck bridge and its open-track approaches.

METHODS

The test was conducted on a multi-span, 525-foot-long open-deck bridge with a newly installed wood-tie deck (with 15-inch ties on center spacing) in a 6-degree curve with a 0.66-percent downhill grade from west to east.

Table 1 describes the test zones, components, and locations on the bridge.

Table 2, on the next page, lists the test zones, as installed, to describe the differences and conditions that may affect performance in a rail fastening system. The number and configuration of the plate-to-tie hold-down fasteners were not specified. The NS bridge department used an appropriate design for this special application. Under-plate rubber pads, an NS standard component on open-deck bridges, were installed throughout the bridge. Under-tie pads were not installed in the approach test zones.

Table 1. Test Zones and Components

Fastening System	Test Zone (No. of ties/track feet)	Plate Size	Hold Down	Rail Fastener
Test Zones 1a (approach) and 1b (bridge) Pandrol 16” Cast Plate West End	30 ties in the open-track approach/49’ @ 19.5” spacing AND 100 ties on the bridge/125’ @ 15” spacing (Total: 130 ties/174’)	16” L by 7.75” W	High Strength Screw Spikes	e-Clips
Test Zone 2 (bridge) Vossloh BTE-30 16” Rolled Plate	90 ties on the bridge/113’ @ 15” spacing	16” L by 8” W	High Strength Screw Spikes	SKI-30
Test Zones 3a (bridge) and 3b (approach) Control Zone – Pandrol 18” Victor Rolled Plate East End	150 ties on the bridge/188’ @ 15” spacing AND 30 ties in the open-track approach/49’ @ 19.5” spacing (Total: 180 ties/237’)	18” L by 8” W	Cut Spikes	e-Clips

RESULTS

The gage strength (resistance to gage spreading force) of each test zone was measured using an LTLF, which applies gage spreading loads and measures the resulting rail displacement.

Gage stiffness of the fastening systems zones was measured using 2 kips and 6 kips of gage spreading load applied to the railhead.

Table 2. Test Zones, Differences, and Conditions

	Test Zones 1a (approach) and 1b (bridge) Pandrol Cast Plate System West End	Test Zone 2 (bridge) Vossloh BTE-30 System	Test Zones 3a (bridge) and 3b (approach) Pandrol Victor System East End
Tie Plate	16”	16”	18”
Rail Clip	e-Clips	SKI-30	e-Clips
Rail Base Shoulder	Cast, part of the plate	Rolled plate	Swaged into the rolled plate
Rail Clip Location	Directly opposed	Directly opposed	Diagonally opposed
Plate-to-Tie Hold-Down Fasteners	Screw Spikes: 2 field side, 2 gage side Cut Spikes: 1 field side, 1 gage side	Screw Spikes: 2 field side, 2 gage side Cut Spikes: 1 field side	Cut Spikes: 3 field side, 2 gage side
Test Zone Location	On the bridge and open-track approach	On the bridge only	On the bridge and open-track approach
Tie Spacing	15” on the bridge/19.5” open-track approach	15” on the bridge only	15” on the bridge/19.5” open-track approach
Under-Plate Rubber Pads	Bridge zone only, none in approach zone	Yes	Bridge zone only, none in approach zone

Figure 2 shows the gage spreading; i.e., the sum of the lateral displacement measured at the rail base and railhead of both rails resulting from the 6-kip applied load, obtained in 2013 and 2014.

The results indicate negligible gage strength differences between the 2013 and the 2014 tests. Test zones 1a (Pandrol 16-inch cast plates at the west approach), 1b (Pandrol 16-inch cast plates on the bridge), and 3b (Pandrol 18-inch Victor at the east approach) performed similarly.

Results in test zones 1b and 3a, however, indicate that the track gage (as measured at the railhead) in zone 3a widened about 2.4 times more than in zone 1b under the same load. The same comparison of the rail base measurements indicates 3 times more widening in zone 3a than in 1b.

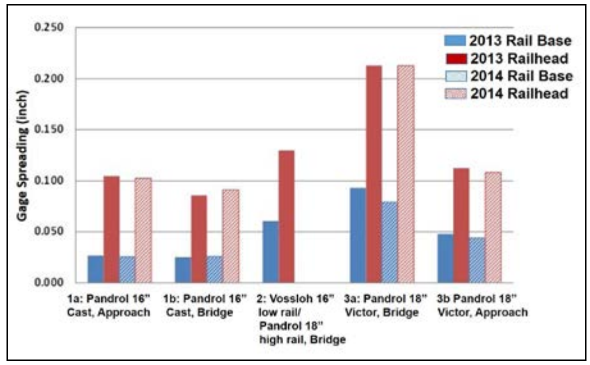

Figure 2. Gage Spreading

Zone 3a and zone 1b are on the bridge, both fitted with rubber under-tie pads, and both use e-clips. Table 2 shows the differences between these two zones, which include type and number of plate-to-tie hold-down hardware, rail clip location, and the size of the tie plates.

The test results indicate that the highest difference in low rail versus high railhead displacement was measured in zone 3a, where the high rail was 2.4 times higher than the low rail.

The Vossloh fastening system on the high rail of test zone 2 had been replaced with the Pandrol 18-inch Victor system when the gage strength test was conducted in 2013. The low rail was still fitted with the Vossloh system. Test zone 2, therefore, became a hybrid and an opportunity to evaluate the performance of the two systems.

The railhead displacement measured on the high rail of test zone 2 (on the bridge), fitted with the Pandrol 18-inch Victor plate system, was 4.6 times more than that measured on the low rail, fitted with the Vossloh 16-inch plate system.

In July 2011, NS reported that 17 Vossloh rail clip bolts broke on the high side of test zone 2 while replacing a rail flaw, some of them broke during installation. In September 2014, NS reported that rail clip bolts broke on the low side in the process of replacing worn rail. As a result, test zone 2 was removed. No broken rail clip bolts were reported at FAST.

One Pandrol 16-inch cast plate broke along the rail base shoulder on the field side. A similar failure mode has occurred at FAST.

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KEYWORDS

Rail fastening systems, track gage strength, bridges, open-deck bridges