



U.S. Department
of Transportation
**Federal Railroad
Administration**



RR 11-18 | September 2011

EFFECT OF MISSING OR BROKEN FASTENERS ON GAGE RESTRAINT OF CONCRETE TIES

SUMMARY

From 2009 to 2010, the Transportation Technology Center, Inc., measured the gage restraint of a mainline concrete tie track affected by missing or broken fasteners. Measurements were taken at the Facility of Accelerated Service Testing (FAST) and in revenue service.

A concrete tie rail fastener (Figure 1) provides gage restraint by holding down the base of the rail with tie clips and by holding the sides in place with insulators pressing against the base of the rail. Missing or broken fasteners can reduce the track's gage strength. This research showed the following:

Missing or broken field side clips were found to have less effect on gage restraint than missing or broken gage side clips. However, missing field side insulators had a greater effect on gage restraint than missing gage side insulators. Gage side clips appeared to play a bigger role than field side clips in preventing gage widening as a result of rail roll. In contrast, field side insulators had a bigger role than gage side insulators in resisting gage widening because of rail translation.

It took eight consecutive ties missing only clips or insulators to reduce gage restraint below the maximum limit. When both clips and insulators were missing, however, it took only three consecutive ties to reduce gage restraint below the maximum limit.

The research presented in this report addresses one of the concerns for the performance of concrete ties under heavy axle load (HAL) train operations, including missing or broken fasteners, rail seat abrasion, pad wear, loss of toe load (hold-down force), improper fastener configuration, and excessive lateral rail movement.

The research is funded jointly by the Federal Railroad Administration (FRA) and the Association of American Railroads (AAR) under the HAL revenue service testing program.



Figure 1. Example of Rail Fastener for Concrete Tie Track (note that the clip shown is not engaged on the rail)



BACKGROUND

Gage restraint is a key requirement for track integrity and track strength. It maintains proper track gage for safe train operations. For a concrete tie track, gage restraint is provided primarily by rail fasteners. A rail fastener (Figure 1) often consists of a plate, a pad, two insulators, and two clips on the gage and field sides of the rail.

A rail clip, when engaged on the base of the rail, provides gage restraint through toe load (hold-down force). In contrast, an insulator provides gage restraint through its lateral resistance against the base of the rail.

For concrete tie track under HAL operations, FRA and railroads are concerned about several issues from both safety and maintenance perspectives, including missing or broken fasteners, rail seat abrasion, pad wear, loss of toe load, improper fastener configuration, and excessive lateral rail movement. This research addresses the issue of the missing or broken fasteners.

OBJECTIVES

During HAL train operations, it is inevitable that some rail fastener components, such as clips and insulators, will break or become loose over time (Figure 2 shows an example). As such, there are questions concerning how track integrity or gage restraining capability by rail fasteners may be compromised as a result of failed or missing fasteners and how different parts of a fastener system can affect gage restraint (gage strength). Answers to these questions provided by actual field testing and

measurements may help railroads develop and optimize their track maintenance practices.



Figure 2. Example of Missing Fasteners in Revenue Service

METHODS

Tests were conducted at FAST and in revenue service. At FAST, the concrete tie track that was tested uses the fastener system shown in Figure 1. At the revenue service western mega site located near Ogallala, NE, the concrete tie track uses the fastener system shown in Figure 2, which is, however, missing clips and insulators. Tests were conducted on both tangent and curve track locations.

A portable track loading fixture (PTLF) was used to measure gage strength. At each test location, a gage widening force of 9,000 pounds was applied to the gage face five-eighths of an inch from the top of the railhead. (Note: The common method of applying load using PTLF is on the rail web with lower force.) Lateral rail deflections were measured at the head and base of both rails. For the specific gage



widening test load, higher deflections correspond to lower gage strength.

Testing with the PTLF does not consider the hold-down moment produced by vertical wheel forces. Therefore, a test using Transportation Technology Center, Inc.'s (TTCI) Track Loading Vehicle (TLV) was conducted at FAST to verify the findings obtained using the PTLF.

RESULTS

Figure 3 shows the test results at FAST. The top graph shows the test results when the field side clips were removed, and the bottom graph shows the test results when the gage side clips were removed. Removal of the field side clips (up to nine ties) had little effect on gage strength, but removal of the gage side clips had a more significant effect. As each additional individual gage side clip was removed, gage widening increased under the 9,000-pound gage widening force.

The results indicate that clips provide gage restraint by preventing rail roll. As such, toe load provided by clips on the gage side of the rail plays a much bigger role in preventing gage widening than clips on the field side of the rail.

Similar to test results obtained at FAST, the revenue service test showed that missing clips (up to nine consecutive ties) on the field side of the rail had less effect on gage strength than missing clips on the gage side of the rail. However, missing insulators on the field side of the rail had more effect on gage restraint than missing insulators on the gage side of the rail. Apparently, insulators provide gage restraint through their lateral resistance to the base of

the rail. As such, the field side insulators, rather than those on the gage side, are loaded when gage widening occurs.

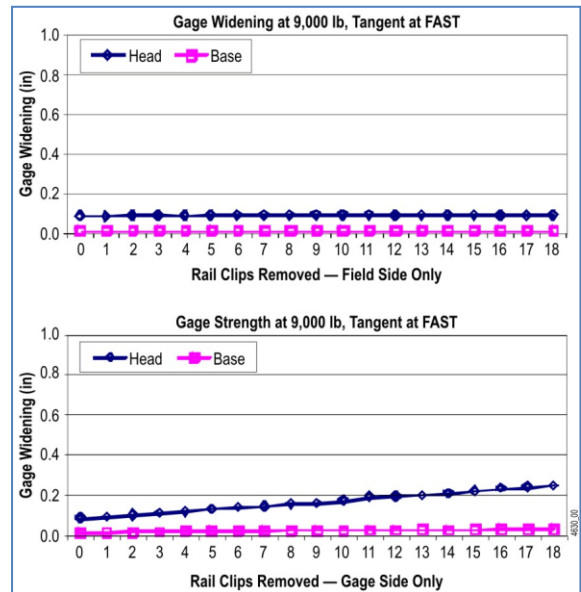


Figure 3. Gage Widening as a Result of Missing Rail Clips at FAST

Figure 4 shows the test results for a tangent and a 2-degree curve track in warm weather conditions and for the same track in cold weather conditions. The results were obtained when the clips and insulators were removed one by one on both the gage and field sides for up to nine consecutive ties (a total of 36 clips and insulators). As illustrated, when all nine ties had their clips and insulators removed, the maximum gage spreading measured 0.97 inch (in). Changes in temperature did not cause significant variations in the results. Between the tangent and 2-degree curve, however, it appeared that the effect of missing fasteners was slightly greater for the tangent track.



In April 2010, a TLV test was conducted at FAST, and the results verified the findings obtained using the PTLF.

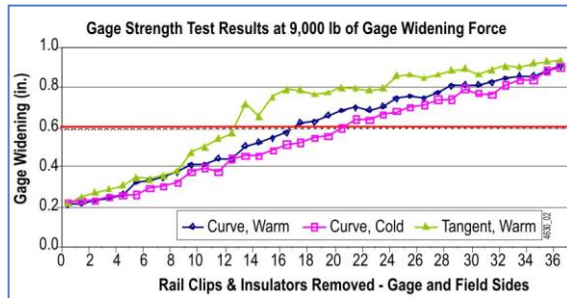


Figure 4. Gage Widening Test Results in Revenue Service

CONCLUSIONS

To determine how many fasteners can be allowed to fail before compromising track strength and integrity, a magnitude of 0.6 in was estimated to be the gage widening limit at the 9,000-pound gage widening force produced by the PTLF. When this estimated gage widening limit is compared with the test results obtained, the following conclusions can be drawn: (1) In the case where only clips or insulators were missing, it took eight consecutive ties to reduce gage restraint below the allowable limit; (2) When both clips and insulators were missing, as shown in Figure 4, it took only three consecutive ties to reduce gage restraint below the allowable limit.

ACKNOWLEDGMENTS

TTCI conducted this research under the joint funding from FRA and the Association of American Railroads. Dr. Dingqing Li and Rafael Jimenez, TTCI, were the principal investigators.

CONTACT

Luis Maal
Resident Engineer
Federal Railroad Administration
Office of Railroad Policy and Development
55500 DOT Road
Pueblo, CO 81001
(719) 584-0551
luis.maal@dot.gov

Gary Carr
Chief – Track Division
Federal Railroad Administration
Office of Railroad Policy and Development
1200 New Jersey Avenue, SE – Mail Stop 20
Washington, DC 20590
(202) 493-6354
gary.carr@dot.gov

KEYWORDS

Gage restraint, concrete tie, broken or missing fastener

Notice and Disclaimer: This document is disseminated under the sponsorship of the United States Department of Transportation in the interest of information exchange. Any opinions, findings and conclusions, or recommendations expressed in this material do not necessarily reflect the views or policies of the United States Government, nor does mention of trade names, commercial products, or organizations imply endorsement by the United States Government. The United States Government assumes no liability for the content or use of the material contained in this document.