TECHNOLOGY DIGEST
TD-08-024
©JUNE 2008
TIMELY TECHNOLOGY TRANSFER

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

Update of Heavy Axle Load Revenue Service Testing at Mega Sites

Dingqing Li (TTCI), Dwight Clark (UP),
Russell McDaniel (NS), and Leonard Allen (FRA)

Summary

In 2007, most revenue service experiments at the eastern and western mega sites continued. Transportation Technology Center, Inc. conducted the experiments in cooperation with Norfolk Southern and Union Pacific.

Premium test rails at both mega sites continue to show excellent wear resistance, losing less than 2.1 percent of the total head area after 114 MGT in the 10-degree test curves at the eastern mega site, and less than 2.4 percent after 494 MGT in the 2-degree test curves at the western mega site. Without preventive grinding in the test curves, rolling contact fatigue (RCF) developed after 300-350 MGT on the low rails in the 2-degree test curves at the western mega site. Corrective grinding was required at 375 MGT to remove RCF. At the eastern mega site, wide gap welds continue to show good performance with no surface or internal defects identified after 123 MGT of traffic.

The plastic tie and elastic fastener test zones at the eastern mega site have accumulated 172 and 145 MGT, respectively, with no major performance problems. Seven of the eight bonded insulated joints (IJ) with the 3-tie plate support design that were installed in July 2004 are still in service with a total of 810 MGT accumulated tonnage, which is approximately four times the average life of earlier IJ designs.

The preliminary phases of the bridge approach test were concluded at both sites. At the eastern mega site, the aim was to investigate the problem causes of open deck steel bridges in curves, while at the western mega site, the load environment for concrete tie ballasted deck bridges was determined. Preliminary results for the bridge approach remedies initiated in the fall of 2007 at both sites have shown good performance.

Two new experiments were initiated at the western mega site in 2007. One experiment was established to monitor the effectiveness of rail anchors with an insulator used for concrete tie track. These anchors are designed to provide additional resistance in preventing loss of toe load and rail longitudinal movement at locations such as turnouts and insulated joints. The other experiment was initiated to test an improved foundation to address performance issues of a crossing diamond.

Most experiments at the mega sites are conducted to supplement and complement the Facility for Accelerated Service Testing (FAST) program with a wider range of operation, track and environmental conditions. In conjunction with the FAST program, the revenue service testing program is designed to determine the effects of heavy axle load (HAL) traffic on track infrastructure and monitor new technologies and designs intended to mitigate detrimental effects of HAL on the track structure.

Please contact **Dingqing Li (719) 584-0740** with questions or concerns regarding this *Technology Digest.* E-mail: Dingqing_Li@ttci.aar.com.

INTRODUCTION

In 2007, the HAL revenue service testing continued at the eastern and western mega sites. This is an update of the ongoing experiments conducted by Transportation Technology Center, Inc. (TTCI), in cooperation with Norfolk Southern (NS) and Union Pacific (UP), and jointly funded by the Association of American Railroads (AAR) and Federal Railroad Administration (FRA).

Eastern mega site:

- Premium rail test (133 MGT since August 2005)
- Wide gap weld test (123 MGT since October 2005)
- Plastic tie test (172 MGT since November 2004)
- Elastic fastener test (145 MGT since June 2005)
- Bridge approach test (Phase I completed)
- Top-of-rail friction control (concluded)

Western mega site:

- Premium rail test (529 MGT since September 2005)
- Bonded insulated joint test (810 MGT since July 2004, concluded)
- Bridge approach test (Phase I completed)
- Rail neutral temperature monitoring (ongoing since September 2005)
- Rail anchor test (started July 2007)
- Crossing diamond test (started July 2007)

The eastern mega site is located near Princeton, West Virginia, on a coal route of NS. The western mega site is located near Ogallala, Nebraska, on a coal route of UP. Both mega sites were established in 2004 to consolidate various revenue service experiments carried out (1) to study the effects of HAL on track infrastructure and (2) to monitor performance of new technologies, new materials, new and improved designs, and improved methods and procedures intended to mitigate detrimental effects of HAL on track infrastructure. Most experiments, installed for the second objective, have been conducted first or concurrently at FAST near Pueblo, Colorado.

2007 EXPERIMENTS

Premium Rail Test

A premium rail performance test was initiated at both mega sites in the fall of 2005. All together, 10 different types of premium rails from 6 manufacturers were installed in 7 curves (6.8- to 10-degree curves at the eastern site and 1- to 2-degree curves at the western site) to measure their performance under different track and operational conditions. Similar rail types were also installed in a 5-degree curve for performance monitoring under 39-ton axle load operation at FAST.

A *Technology Digest* (TD) has been published to summarize performance results of all premium rails through the end of 2007, and their comparison with the results at FAST.[1] In general, all premium rails have shown excellent resistance to rail wear under HAL traffic. The rail wear life of those premium rails was estimated to be at least 1,000 MGT for a 10-degree curve at the eastern mega site with excellent gage face and top of rail friction control, and 2,800 MGT for a 2-degree curve at the western mega site without ideal lubrication.

RCF developed on only the low rails for the 2-degree curve at the western mega site after 300-350 MGT (without preventive grinding for testing purpose). A corrective grinding was required to remove RCF at 370 MGT.

Bridge Approach Test

A bridge approach test has been ongoing at both mega sites. At the eastern mega site, an investigation was completed in 2007 to identify the causes for excessive maintenance requirements for open deck steel bridges located in curves and spirals. At the western mega site, work was completed to determine load environment and quantify track responses for ballast deck concrete bridges with concrete ties under as-is track condition. Two TDs have been published to summarize the results and findings from the earlier testing.[2,3]

In the fall of 2007, the bridge approach test proceeded to the second phase; i.e., installation of remedies at both mega sites. At the eastern mega site, two bridges at a 10-degree curve had their open decks replaced with ballast deck to address misalignment problems associated with the bridges.[3] The foundation at the approaches was also strengthened with added gravel and rock. Prior to this remedy work, lateral track strength (gage strength and panel shift strength) was significantly different from the approaches to the bridges, causing track misalignment in this 10-degree curve. After the remedy work, lateral track strength has become consistent, allowing the track to move in a consistent manner from the approaches to the bridges. For example, Figure 1 shows a comparison of gage strength (delta gage = loaded gage – unloaded gage) before and after the work.

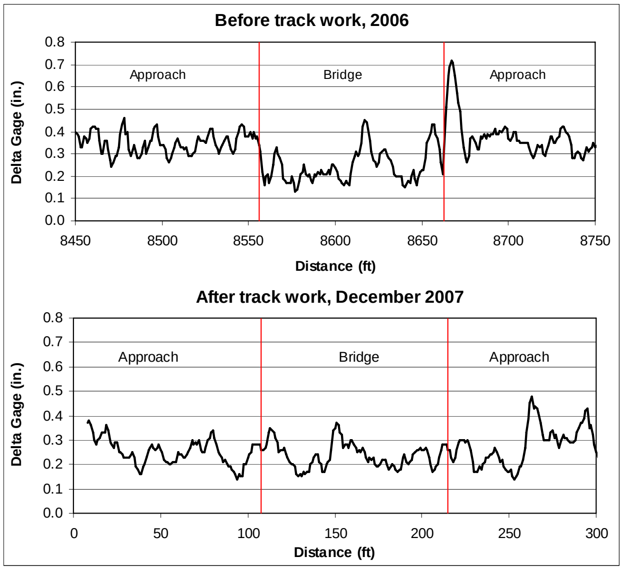

Figure 1. Gage Strength before and after Deck Replacement

At the western mega site, Phase I testing was also concluded, showing that the dynamic load environment and track responses for the bridge and its approaches were severe under the as-is condition.[2] In September 2007, the standard concrete ties were replaced with ties fitted with rubber pads on the bottom surface to improve track resiliency and damping for the track on the bridge. This remedy was proven effective for the bridge approach test at FAST. As part of the remedy installation at this site, ballast undercutting was done to remove excessive fouling materials.

Monitoring of track performance is currently ongoing. Preliminary results have shown significant improvement of track performance with reduced impact wheel loads and track responses recorded. Figure 2 shows a 30 percent reduction of dynamic bending strain measured at the bottom of the bridge beam.

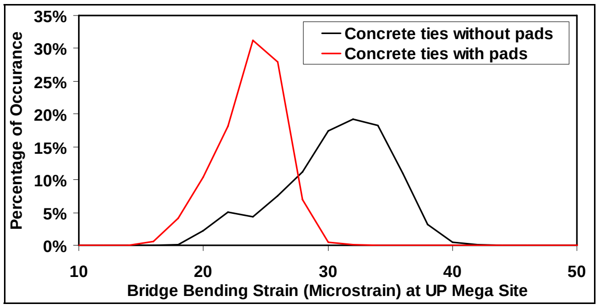

Figure 2. Improvement of Track Response

Wide Gap Weld Test

Two types of wide gap welds (Orgo Thermite and Railtech Boutet) have been under performance testing at the eastern mega site. One type was installed in October 2005, and the other type was added to the test site one year later. As compared to 1-inch standard welds, wide gap welds (2.75 inches) can prevent use of two welds when a rail defect needs to be removed or can reduce large change of rail neutral temperature when a broken rail can be welded without heating or pulling.

At the end of 2007, 123 MGT was accumulated on the first type of wide gap welds, and 66 MGT was accumulated on the second type of welds. For both types of welds, their performance has been good. No surface and internal defects (from handheld ultrasonic inspections) have been identified for the 32 test welds installed at this mega site.

Plastic Tie Test

Two types of plastic ties (Polywood and TieTek) have been under test at the eastern mega site since November 2004. An earlier TD summarizes their preliminary performance results.[4] At the end of 2007, approximately 172 MGT of traffic was accumulated in the test zones, and plastic ties continued to support HAL train operation with good performance.

Performance measurements have included track geometry, gage strength, lateral rail deflection, and vertical track deformation under train passes. In general, issues associated with plastic ties observed at this mega site have been consistent with those observed at FAST, including tie cracking due to spiking without pilot holes and higher vertical deformation (or pumping) due to lower bending stiffness of plastic ties (compared to wood ties). However, no plate breakage has been identified at this mega site; although a few broken plates were identified on the plastic ties at FAST.

Elastic Fastener Test

Two types of elastic fasteners (NorFast and AirBoss) have been under test at the eastern mega site since June 2005. A published TD summarizes their preliminary performance results.[5]

As expected, the test zones (wood tie track) with elastic fasteners showed higher gage strength, higher rail roll resistance, and lower lateral rail deflection than the control test zone with cut spikes. At the end of 2007, 145 MGT was accumulated for this test, and no major performance problems have been observed for either type of elastic fastener.

Two broken clips (out of 360 in the test zone) were identified for one type of elastic fastener (NorFast) after 70 MGT. Because of similar clip breakage (nine out of 260), after 455 MGT at FAST, a laboratory study was conducted on the samples taken from the ongoing in-track tests at the eastern mega site as well as at FAST to help determine if this type of clips should be removed from service testing.[6] The results of this laboratory study indicated that no such action was necessary at this time. As of the end of 2007, there have been no additional rail clip failures and none of the clips has come loose.

Top-of-Rail Friction Control Test

Top-of-rail (TOR) friction control monitoring started at the eastern mega site in 2004, and this test was mostly concluded in 2007. As part of an overall AAR and FRA research program in TOR friction control, this test showed significant benefits of TOR friction control in reducing lateral wheel/rail force, reducing gage widening, reducing rail wear, and reducing growth of rail surface defects.[7] In addition, this test provided data in optimizing TOR friction modifier application in terms of application rate and the wayside application system setup.

Although this test was essentially concluded in 2007, a lower level of monitoring effort will continue to be made, using the TOR equipment implemented and wayside monitoring devices already in place to support NS's operation in the area.

Bonded IJ Test

The bonded IJ test was initiated at the western mega site in the summer of 2004 and concluded in 2007. Lower level monitoring effort will continue for the test IJs that remain in service.

Under this test, eight test joints were installed and instrumented at four different locations. Seven IJs have a supported foundation (i.e., the length of IJ rests on a plate over three ties, with a tie directly under the end post); and one was an early conventional design (i.e., the end of post suspended between two ties without a three-tie support plate). An earlier TD summarizes the findings and conclusions of this test.[8] The suspended IJ failed at 330 MGT, but the other seven supported on a 3-tie support continue in service, with an accumulated traffic of 810 MGT, approximately four times the average life of past IJ designs.

Rail Neutral Temperature Monitoring

Monitoring neutral rail temperature in a 2-degree curve started at the western mega site in October 2005 and continued in 2007. The objective was to monitor how rail neutral temperature in a curve with concrete ties would change due to traffic, ambient temperature change, and track maintenance activities.

The data collected was incorporated into another AAR research initiative in developing rail stress management guidelines.[9] A magazine article summarizes the test results and findings obtained from this experiment at the western mega site.[10]

Rail Anchor Test

This was a new test installed at the western mega site in July 2007. Under this test, rail anchors with plastic cover (insulator) are used on the concrete tie track to provide additional longitudinal resistant to prevent loss of toe load over time and prevent longitudinal rail movements at locations such as turnout and insulated rail joint.

Three IJ locations were selected for this test. At each location, rails on one side were fitted with anchors, whereas the rails on the other side were without anchors (see Figure 3). Ongoing measurements include monitoring changes in toe load and rail neutral temperature over time between the rails with anchors and the rails without.

Figure 3. Rails with and without Anchors at Western Mega Site

Crossing Diamond Test

This was also a new test initiated at the western mega site in 2007. Under this test, improvement was made to the foundation of a crossing diamond between two mainline tracks at the western mega site (Figure 4), which experienced rapid component breakage and rail running surface degradation as a result of high impact wheel forces. At this location, weekly maintenance work was required with constant slow orders. The improvement made to the foundation included use of rubber pads between tie plates and ties to provide resiliency and damping to attenuate high impact wheel forces generated over the crossing diamond, and use of longitudinal ties under the track with higher tonnage (rather the other way around), which would lead to a more uniform deformation between the two tracks with different tonnages.

The improvement was made in August 2007, but was not considered a permanent solution because of inherent issues related to the design of this type of crossing diamond, including discontinuities of the running surfaces and metal to metal contacts between the castings and the tie plates (Figure 4). Nevertheless, initial feedback from the local track maintenance personnel was positive in terms of reduced track maintenance requirements. Measurements of vibration from rail to tie and running surface degradation have been taken to generate a database that will be used to quantify any improvements that can be made, including the ones installed in August 2007.

Figure 4. Diamond Crossing at Western Mega Site

FUTURE WORK

In 2008, most experiments will continue. New experiments will address other HAL track degradation issues, such as mud hole problems on HAL coal routes and pad degradation/rail seat abrasion issues of concrete ties. In conjunction with the testing program at FAST and other AAR research initiatives, revenue service testing will continue to facilitate implementation of HAL train operation on North American railroads.

REFERENCES

1. Li, D., S. Atkinson, and R. McDaniel. February 2008. “Interim Performance Results of Premium Rails in Revenue Service at Mega Sites.” *Technology Digest* TD-08-008. Association of American Railroads, Transportation Technology Center Inc., Pueblo, CO.

2. Li, D. et al. December 2007. “Dynamic Load and Track Response: Bridge Approach Test at the Western Mega Site.” *Technology Digest* TD-07-042. AAR, TTCI, Pueblo, CO.

3. Li, D., C. Duran, and R. McDaniel. August 2006. “Investigation of Open Deck Bridge Transition Issues at the Eastern Mega Site.” *Technology Digest* TD-06-022. AAR, TTCI, Pueblo, CO.

4. Jimenez, R., D. Li, and R. McDaniel. February 2006. “Preliminary Performance of Plastic Ties in Revenue Service at the Eastern Mega Site (Norfolk Southern).” *Technology Digest* TD-06-005. AAR, TTCI, Pueblo, CO.

5. Jimenez, R., D. Li, and R. McDaniel. October 2007. “Preliminary Performance of Elastic Fastening Systems in Revenue Service at Eastern Mega Site.” *Technology Digest* TD-07-031. AAR, TTCI, Pueblo, CO.

6. Robles, F., R. Jimenez, and W. Larson. November 2007. “Laboratory Study of Norfast Rail Clips.” Letter Report for HALERC, TTCI. AAR, TTCI, Pueblo, CO.

7. Reiff, R., K. Conn, and D. Li. March 2006. “Eastern Mega Site Wayside Top-of-Rail Friction Control Implementation Status.” *Technology Digest* TD-06-006. AAR, TTCI, Pueblo, CO.

8. Li, D. et al. December 2006. “Measurement of Load Environment and Performance of Insulated Joints at Western Mega Site.” *Technology Digest* TD-06-028. AAR, TTCI, Pueblo, CO.

9. Read, D. and A. Kish. April 2006. “Methodology for More Efficient Continuous Welded Rail Management through Improved De-Stressing and Neutral Temperature Readjustment - Part 1 of 2.” *Technology Digest* TD-06-010. AAR, TTCI, Pueblo, CO.

10. Read, D. et al. June 2006. “Monitoring Rail Neutral Temperature Behavior in Revenue Service” RT&S.