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Update of Experiments at Western Mega Site

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SUMMARY

In 2006, four track experiments were in progress at the western mega site located on a Union Pacific (UP) heavy haul coal line in the South Morrill Subdivision, Nebraska. These experiments included the bonded insulated joint (IJ) test, bridge approach test, premium rail performance test, and rail stress management by neutral temperature monitoring. The following is a summary of the main findings and achievements of the western mega site at the end of 2006:

- IJs supported on 3-tie plates have been in service 536 MGT, twice as long as the average life of past IJ designs.
- One suspended IJ failed at 330 MGT when a joint bar cracked due to fatigue damage.
- To further extend IJ life, design should be focused on reducing vertical impact loads, reducing vertical IJ deflection, and limiting the pull force that will create rail neutral temperature above 120°F.
- The load environment for a ballast deck concrete bridge with concrete ties was quantified to be severe (large impact loads at least twice as high as static wheel load) and has caused cracked ties, rough track geometry, and mud pumping for the track on the bridge as well as in the approach.
- All premium test rails under testing have performed well, showing only minor wear and surface checks after 275 MGT of traffic.
- Monitoring of neutral rail temperature has produced valuable data regarding the effects of traffic, temperature variation, broken rails, track maintenance activities, and panel shift. The data is used for developing efficient rail stress management practices.

The Mega Site Test Program was established in 2004, under joint funding by the Association of American Railroads and Federal Railroad Administration, to consolidate various revenue service test activities into two mega sites: one in the east with Norfolk Southern Railroad and the other in the west with UP. Each mega site is 10 to 30 miles long and located in the heavy haul coal lines.

The objectives of the revenue service mega site programs are to evaluate the effects of heavy axle loads (HAL) on track infrastructure and to monitor the performance of new technologies, new materials, and improved design and maintenance practices first tested at Facility for Accelerated Service Testing to mitigate the effects of HAL traffic.

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INTRODUCTION

At the western mega site on a UP heavy haul coal line located in the South Morrill Subdivision in Nebraska, four experiments were in progress in 2006, including:

- Bonded IJ test
- Bridge approach test
- Premium rail performance test
- Neutral rail temperature monitoring

The western mega test site was established in 2004 under a joint research program funded by the Association of American Railroads (AAR) and Federal Railroad Administration (FRA). The objectives of this program are to determine the effects of HAL on track infrastructure and to monitor the performance of new technologies, new materials, and improved design and maintenance practices intended to mitigate the effects of HAL traffic.

The annual tonnage at the western mega site is approximately 220 MGT per year, with 80 percent being 286,000-pound capacity unit coal trains running at 50 mph east bound. The track typically has shallow curves (1 to 2 degrees) and primarily uses concrete ties with elastic fasteners.

This *Technology Digest* summarizes the results and preliminary conclusions to date.

BONDED IJ TEST

The bonded IJ test began in the summer of 2004. Eight IJs were instrumented and installed at four different locations between milepost (MP) 36 and MP 54, all on tangent track with concrete ties. Among them, six are used on 141 RE rails with 8-hole joint bars (48 inches), and two are used on 133 RE rails with 6-hole joint bars (36 inches). Seven IJs have a supported foundation (i.e., the length of the IJ rests on a plate over three ties, with a tie directly under the end post), and one is on a suspended foundation (i.e., the end post is suspended over the ballast crib, and there is no multi-tie plate). Figure 1 shows a supported IJ (141 RE rail) and a suspended IJ (133 RE rail).

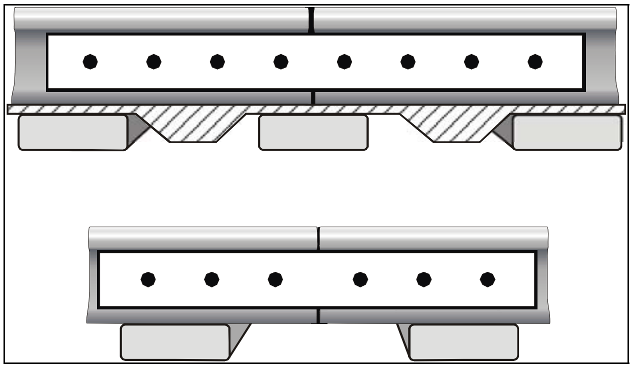


Figure 1. Supported IJ (top) and Suspended IJ (bottom)

Instrumentation was installed on the rails and joint bars to measure longitudinal rail force, vertical impact load, and bending stress in joint bars, all of which are load parameters critical to IJ performance.

At the end of 2006, approximately 536 MGT of traffic was accumulated for this experiment. *Technology Digest* TD06-028 describes this experiment and test results in detail. The following is a summary of the findings to date:[1]

Bonded IJs supported on a 3-tie plate have been in service twice as long as the average life of past IJ designs. Although total maximum tensile stress due to bending and temperature change was measured lower than the nominal yield strength of a joint bar, a bar on a suspended joint cracked due to fatigue at 330 MGT during a cold winter. Improvements in IJ designs that can accomplish the following will extend IJ service life greatly: reduce vertical impact loads, reduce vertical deflection of joints, and limit the pull force used to install an IJ plug that may create a high neutral rail temperature above 120°F.

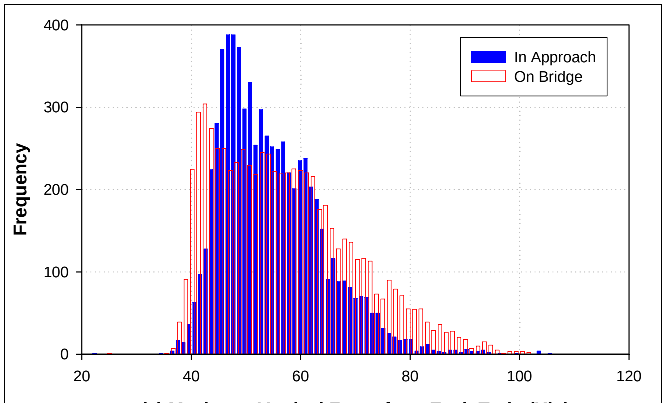
BRIDGE APPROACH TEST

The bridge approach test, which began in September 2005, involves a short-span (10-foot) ballast deck concrete bridge with concrete ties. This experiment was designed to achieve the following goals:

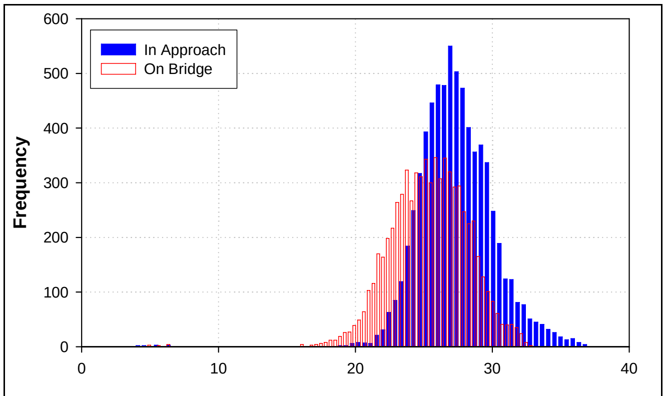
- Quantify the load environment and track performance for the as-is track condition (Phase 1), which is scheduled to conclude in the spring of 2007
- Quantify the load environment and track performance for improved track designs (concrete ties with rubber pads at the bottom – Phase 2 and use of ballast mat on the bridge deck – Phase 3, both were tested at FAST with positive results)

As reported in *Technology Digest* TD03-013 and TD05-001, ballast deck concrete bridges with concrete ties (as-is condition) often experience significant track maintenance problems such as cracked concrete ties, rough track geometry, and mud pumping due to high impact loads in the area. The underlying causes are differential track settlement, large track stiffness on the bridge, and rapid track stiffness and damping changes between bridges and their approaches. The earlier research also quantified the benefits of the improved track designs in terms of improved track stiffness and damping characteristics.[2,3] The bridge approach test at the western mega site, however, was designed to obtain the actual load environment and long-term track performance data to compare the as-is and the improved track designs (those tested at FAST first) on a concrete bridge.

Figure 2 shows the load environment results collected for the track in the approach and the track on the bridge (summary of dynamic vertical wheel loads from about 7,000 trains that have passed through the test site). Figures 2a and 2b show the maximum and minimum wheel loads for each train.



(a) Maximum Vertical Force from Each Train (Kip)



(b) Lowest Vertical Force from Each Train (Kip)

Figures 2a and 2b. Dynamic Wheel Loads Generated in Approach and on Bridge (Phase 1)

Figure 2a illustrates that a large number of high impact wheel loads, at least twice as high as static wheel loads (36 kips), were generated in both the approach track and the track on the bridge. In addition, the number of high impact wheel loads was even larger on the bridge than in the approach, because the track on the bridge is a lot stiffer and has less damping than the track in approaches.[2,3] Figure 2b shows the minimum wheel loads recorded from each train. Again, the track on the bridge recorded lower minimum wheel loads than the track in the approach, also indicating greater dynamic vehicle/track interaction on the bridge. Nevertheless, as Figure 2 shows, the load environment for both the approach track and track on the bridge is severe for the as-is track condition.

In fact, one year after the start of this experiment, concrete ties on the bridge have started to crack and mud pumping from ballast breakdown under impact loads appeared in both the approach track and the track on the bridge. Figure 3 shows a picture of mud pumping in the approach.

Testing for the as-is condition has produced the baseline results. In the spring of 2007, the track at this site will undergo a ballast undercutting operation and the ties on the bridge will be replaced with ties fitted with rubber pads underneath (Phase 2). The same measurements and monitoring will be repeated to quantify how the actual load environment will change and how track performance may improve.

Figure 3. Mud Pumping in the Approach

PREMIUM RAIL PERFORMANCE TEST

The premium rail performance test started in September 2005. Seven premium rail types from six rail suppliers (Nippon, Rocky Mountain Steel Mill, Mittal, JFE, Corus, and Voest Alpine) were installed in three different curves (one 1-degree curve and two 2-degree curves) to monitor their long-term performance under HAL train operation.

In order to determine performance of seven rail types objectively, one rail type was used as the control test rail and in each curve, each of other six rail types was welded together (flash butt welded) with the control rail. Rail performance is evaluated in terms of ratio of test rail/control rail. In other words, the control rail is used to normalize possible condition variations from location to location, even in the same curve.

In each curve, each test rail type was welded in 40-foot lengths and is repeated twice. Performance of test rails is being monitored in terms of rail wear resistance and resistance to rolling contact fatigue. Figure 4 shows the actual hardness measurement results obtained at three MGT levels. As Figure 4 shows, all the test rails have shown hardness above 400 Brinell hardness number (BHN) after about 130 MGT of traffic.

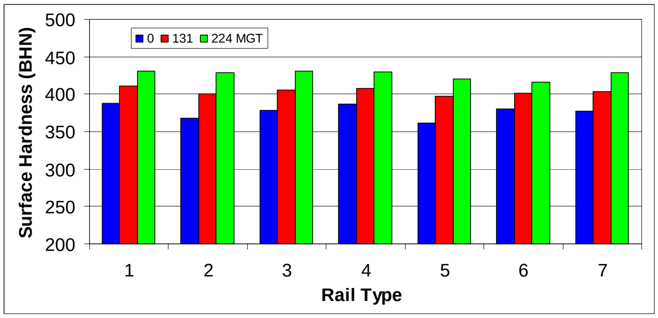


Figure 4. Average Rail Harness Test Results

At the end of 2006, approximately 275 MGT of traffic had accumulated on these test rails. To date, all test rails have performed well with only minor wear (Figure 5 shows the average head area loss for the high rail in a 2-degree curve). Some rails have also shown minor surface checks and corrugations.

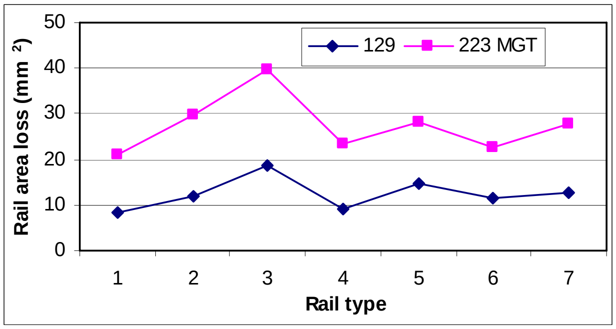


Figure 5. Average Rail Wear (High Rail in 2-Degree Curve)

NEUTRAL RAIL TEMPERATURE MONITORING

Monitoring of neutral rail temperature in a 2-degree curve started in October 2005. In this curve, a number of neutral rail temperature monitoring modules were installed at an interval of 100 or 150 feet. The objective of this experiment is to monitor how neutral rail temperature in a curve with concrete ties changes due to traffic, temperature change, and maintenance activities. The data collected will help develop more effective continuous welded rail (CWR) stress management practices.

Figure 6 shows the measurement results of neutral rail temperature from three modules installed in this curve. In this graph alone, a great deal of information is included, showing how traffic would reduce neutral rail temperature following the initial rail welding, how neutral rail temperature fluctuated from daily temperature variation, how a broken weld caused redistribution of neutral rail temperature 50 to 300 feet away from the broken weld for the track with concrete ties and elastic fasteners, how rail pulling was required in the winter to raise neutral rail temperature to the desire level, and how a panel shift could also reduce neutral rail temperature significantly.

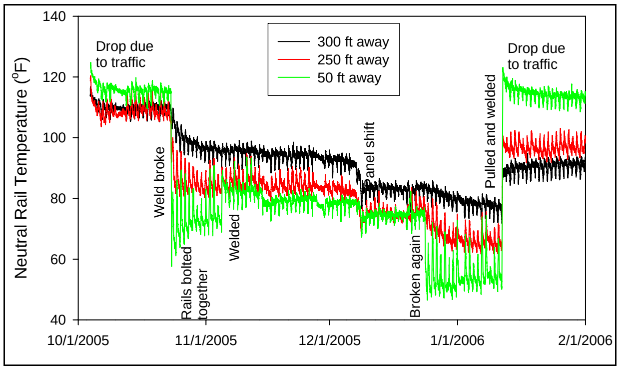


Figure 6. Neutral Rail Temperature Variation

CONCLUDING REMARKS

Findings from the IJ experiment and neutral rail temperature monitoring have been incorporated into two other AAR research projects, Insulated Rail Joints and Rail Stress Management, for developing improved IJ designs and the best practices for managing CWR rail stresses.[4] Final performance results of the premium test rails will be related to those of the rail tests at the eastern mega site as well as under the FAST Experiment Program. All four experiments will continue in 2007. For the bridge approach test, Phase 1 will conclude in the spring of 2007 and will be followed with the Phase 2 experiment. In addition, the following three new experiments will be started at the western mega site:

- Application of isolators (anchors with plastic cover to prevent damage to concrete ties) in IJ locations
- Improved crossing diamond foundation to reduce impacts (also part of the AAR special trackwork project)
- Curve entry guard rails

ACKNOWLEDGMENTS

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