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# Part 2: Heavy Axle Load Revenue Service Mega Site Testing 2005–2012

## SUMMARY

Since 2005, the Federal Railroad Administration and the Association of American Railroads have jointly funded a heavy axle load (HAL) revenue service testing program, with several objectives. One objective is to determine the effects of HAL traffic on track infrastructure by supplementing test activities performed at the Facility for Accelerated Service Testing (FAST) with a wider range of track, operating, and climatic conditions. The second objective is to identify issues that could negatively affect HAL operations and find solutions to address those issues. The third objective is to test and monitor new and alternative track designs and materials, as well as improve track maintenance procedures intended to mitigate adverse effects of HAL traffic on track degradation.

Two revenue service mega sites (see Figure 1) were established for this research: one in the East near Bluefield, WV, and the other in the West near Ogallala, NE. In comparison, the eastern mega site typically has sharp curves (up to 12 degrees) and steep grades (up to 1.4 percent), wood ties, open deck steel bridges, 20 to 40 mph operating speeds, and 55 megaton (MGT) per year tonnage. The western mega site typically has shallow curves (1 to 2 degrees), concrete ties, ballast deck bridges, 40 to 60 mph operating speeds, and tonnage up to 250 MGT per year.

From 2005 through 2012, Transportation Technology Center, Inc. (TTCI), with help from the host railroads, has conducted a number of experiments. Some were designed to address safety items, such as the derailment potential related to broken rails, weld defects, and large wheel-rail forces due to adverse track geometry. Experiments were also designed to examine the effects of HAL on track component degradation, as well as the effectiveness of new and alternative materials, designs, and techniques developed to minimize negative HAL effects.

Part 2 (of two companion articles) gives a summary of experiments in the areas of bridge, tie and fasteners, and special trackwork.

Figure 1: Eastern (top) and Western (bottom) Mega Sites

## CONTINUOUS WELDED RAIL (CWR) AND BRIDGE INTERACTION

In 2010, an experiment was started to characterize the interaction between CWR and an open deck steel bridge at the eastern mega site. The test has a short-term objective to measure CWR-bridge interaction under train traffic and a longer-term objective to measure CWR-bridge interaction due to temperature change.

Under an operating condition with total tractive or dynamic brake efforts less than 100,000 pounds, the test has shown that the longitudinal rail force and movement of rail, tie, and girder due to traffic are unlikely to cause CWR stability issues in the bridge approach. Rail-to-tie displacement was relatively small (note that elastic rail fastening was used) compared with tie-to-girder displacement. In addition, tie-to-girder displacements on a smooth girder surface were found to be greater than those on the girder with rivet heads, a major benefit because of increased longitudinal tie-to-girder resistance.

## ELASTIC FASTENINGS (WOOD TIES)

A test of elastic rail fastening systems was conducted on an 8-degree curve at the eastern mega site. From 2005 to 2010, two types of elastic fasteners were subjected to 260 MGT. Their performance was compared with the standard cut spike system.

Test results show that the wood tie track fastened with the elastic fasteners provided higher gage strength than the track fitted with cut spike. Lateral deflection of the low rail measured under train operations in the cut spike zone was greater than measured on the same rail in the elastic fastener zones. Cut spike uplift of more than 1 inch occurred in almost 4 percent of the spikes (five spikes per tie plate). In the elastic fastener zones (four screw spikes per tie plate), none of the screw spikes uplifted significantly nor fractured during the test.

Eleven of the 360 rail clips from one type of elastic fastening system fractured during the test period. Results of the laboratory test showed that these fractures occurred as an unpredictable or minor consequence of the testing.

## EFFECT OF MISSING FASTENING ON GAGE RESTRAINT (CONCRETE TIES)

In 2009 and 2010, an experiment was conducted to measure gage restraint of concrete tie track affected by missing and/or broken fasteners. Missing and/or broken fasteners reduce gage strength, thus increasing risk of derailment.

Test results showed that missing or broken field-side clips had less effect on gage restraint than missing or broken gage-side clips, whereas missing field-side insulators had greater effect than missing gage-side insulators. It appears that gage side clips play a much bigger role than field side clips in preventing gage widening due to rail roll. Field side insulators play a much bigger role than gage side insulators in resisting gage widening due to rail translation.

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

## COMPOSITE PLASTIC TIES

From 2004 to 2010, two types of plastic ties were tested on a 6.8-degree curve at the eastern mega site. The test ties were subjected to 282 MGT before the test was concluded. The plastic ties tested were capable of supporting HAL traffic with acceptable performance. There were no problems related to track geometry, gage strength, tie plate cutting, cut spike uplift, or fastening system component failure in the test zone. Although gage strength degradation and gage widening were slightly higher in the plastic ties than in the wood ties, the trends were similar. Pilot holes for cut spikes reduced the occurrence of cracks and plastic composite material buildup between the plate and the top of the plastic composite ties during spike insertion.

Test results have shown that plastic composite ties tend to have lower bending stiffness and lower toughness, when compared with wood ties. Different material formulations and manufacturing processes may affect tie toughness, because plastic composite ties from only one manufacturer broke. After 212 MGT, one tie fractured near its center at a void in the plastic composite material. After 280 MGT, four more ties cracked along the cut spike plane from a wedging force created as the spikes were inserted into synthetic tie plugging material.

## BRIDGE APPROACHES

At the eastern mega site, the bridge approach problems were determined to be cross-level differential support over approximately 5 to 10 ties at the ends of bridges caused by skewed abutments and large changes in lateral track stiffness and restraint from bridges to their approaches. A proven remedy is to change from open deck to ballasted deck in order to address the root causes of the problems. From 2007 to 2008, this method was implemented on two bridges located in sharp curves. For approximately 290 MGT and 260 MGT, respectively, these two bridges and their approaches have performed well, and they have not experienced any of the past problems that required surfacing and lining operations on a quarterly basis (15 MGT).

At the western mega site, the root causes of problems were determined to be high stiffness and low damping for tracks on bridges. With standard concrete ties and ballasted deck concrete bridges, track modulus on the bridge was often more than twice as high as that in the approaches. An effective remedy was to reduce stiffness and increase damping, thus reducing impact forces exerted on the track

Two methods have been implemented for two different bridges: (1) replacing standard concrete ties on a bridge with concrete ties fitted with rubber pads on the bottom of ties and (2) using ballast mats between the bridge deck and the ballast. Since their separate installations (with drainage improvement) in 2007 and 2009, track performance has improved, and both methods brought significant economic benefits for HAL and high tonnage lines.

## CROSSING DIAMOND

From 2006 to 2009, TTCI monitored the performance of a diamond crossing at the western mega site. Component breakage and rapid rail running surface degradation required frequent maintenance. The diamond was replaced approximately every 300 MGT on the track carrying higher tonnage.

Investigation has shown that the root causes of the problems are high impact forces resulting from running surface discontinuities and degradation, high contact stresses between castings and plates, inadequate resilience and damping, and irregular deformation due to abrupt changes in track stiffness from large castings and multiple-tie plates. At 25 mph, test results showed vibration of the diamond crossing was at least 3 times as high as that of the adjacent open track.

Several methods were implemented to improve the performance, including installing expansion joints and ramped up running surface profiles, and installing rubber pads under tie plates. However, these methods have not led to improvements that significantly reduce extensive maintenance requirements because they have not addressed flangeway gaps and joints, which are the primary reason for high impact forces at crossing diamonds.

## FUTURE ACTION

In 2013, several new experiments are being implemented, including performance of new premium rails, railhead defect repair welds, optimized methods to control rail RCF, and advanced frog designs in revenue service operations.

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## KEYWORDS

Heavy axle load, track infrastructure, mega sites