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Testing at the Facility for Accelerated Service Testing Summary of 2011 Results

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Summary

Research at the Facility for Accelerated Service Testing (FAST) has continued to provide valuable information to the railroad industry during the past year. This *Technology Digest* provides selected results from 2011, when 149 million gross tons (MGT) was accumulated on the track components and structures were being evaluated. Highlights of these results are as follows.

A new test of premium rails developed to provide better wear and fatigue resistance began in 2010. The rails, produced by suppliers in Europe, North America, and Asia, have accumulated 260 MGT under 39-ton axle loads. Differences between rail types in wear and rolling contact fatigue (RCF) performance are evident. An experimental rail installed after the commercially produced rails has accumulated 170 MGT. Some rails are showing little to no RCF; others are showing heavy RCF.

Half-frame concrete ties, conventional concrete ties, and modified concrete ties installed in 2009 have accumulated 315 MGT. Results to date show that the half-frame ties provide very stable track. A separate test of wood and concrete ties began in 2008. After 425 MGT, softwood ties with cut-spike plates have shown the least gage restraint in the wood tie test. Screw spikes in one test zone were replaced with high-strength screw spikes because of numerous broken spikes. Two types of insulators on concrete ties had to be replaced because of excessive breakage.

Innovative rail welding methods developed by various suppliers are being evaluated. Second generation thermite head-repair welds have accumulated up to 200 MGT. None of the head repair welds installed under typical conditions has been removed. In comparison, approximately 40 percent of first-generation head-repair welds were removed by 100 MGT. Electric flash welds are also being evaluated as a method of railhead repair. The first set of test welds, produced in-shop then installed in track, has accumulated 150 MGT without any removals. A second set of welds made in-track was installed later in the year. One of the eight welds has failed at 36 MGT, but the failure was not related to the repair.

Evaluation of the effects of heavy axle loads (HAL) on concrete bridge spans continues. Four spans of various designs and materials installed in 2003 have accumulated 1,053 MGT, and a prototype span installed in 2011 has accumulated 80 MGT. The prototype span is a hybrid composite bridge (HCB) span with a tied-arch design that has the potential to substantially lower the weight of short to mid-length concrete spans. The HCB span has performed acceptably to date.

Tonnage on a welded steel bridge span fabricated in 1957 and installed at FAST in 1997 has reached 1,808 MGT. Cracks at poor weld details continue to develop and grow. The impacts caused by a lift joint on the bridge increased crack activity. A riveted span built in 1912 was installed late in 2009 to test and evaluate bridge life extension methods under HAL. Performance of the primary structural members has been satisfactory through 260 MGT. Many bracing members were heavily corroded when the span was installed at FAST. Bracing repairs lowered maximum deflections from about 0.3 inch to 0.2 inch. Some of the partially corroded braces have cracked and been repaired since installation.



INTRODUCTION

Evaluations to improve the safety and utility of track components under HAL have continued at FAST located at the Transportation Technology Center (TTC), Pueblo, Colorado. Results for selected tests at FAST from 2011 when 149 MGT was accumulated are presented. The 149 MGT represents the second highest yearly tonnage accumulation in the over 30-year history of the FAST Program. Additional results have been published in other *Technology Digests* (see the Bibliography at the end of this TD).

RAIL EVALUATION

The latest rail test at FAST includes 11 high-hardness (413 HB average) premium rails. The rails have accumulated 260 MGT. In addition to 10 commercially developed rails, an experimental rail developed in a collaborative effort between Transportation Technology Center, Inc. (TTCI) and the University of Pittsburgh and produced by voestalpine AG is also being tested. Table 1 lists the suppliers, types, and head hardness of the premium test rails.

Table 1. Premium Test Rails

Supplier	Rail Type(s)	HB
Tata Steel (France)	MHH HE Mill Head Hardened Hypereutectoid	428
ERMS (USA)	OCP 1-Percent Carbon	406
JFE (Japan)	SP2, SP3 Super Pearlite 2 & 3	406 411
Mittal (USA)	HC High Carbon	416
Nippon (Japan)	HE-X Hypereutectoid X	415
Panzhuhua (China)	PG4	401
voestalpine Schienen (Austria)	VAS 1, VAS 2, 400NEXT	415 401 393

Mechanical properties of the test rails were measured. Two independent laboratories verified the results of tests conducted at TTC. All rails met recommendations of the American Railway Engineering and Maintenance-of-Way Association for hardness and ultimate tensile strength of premium rail. However, some rails did not meet the requirements for elongation or yield strength.

The premium rails were installed in a nonlubricated 5-degree curve. Figure 1 shows rail wear (area loss) for the rails on the high rail of the curve through 200 MGT. Note that the 400NEXT rail was installed later than the other test rails; thus, has accumulated less tonnage. Its wear rate is close to the average of the other test rails.

The rail with the best wear performance has worn about 18 percent less than the rail with the most wear. However, previous testing has shown that relative wear can change as tonnage accumulates, and these results should be considered as preliminary. All rail types are showing some RCF after 260 MGT; visible RCF began to develop after about 100 MGT. Some rails are exhibiting more RCF than others. The severity ranges from very mild to heavy. Figure 2 shows examples of the RCF observed in the test section. The rails with the least RCF show none of the spalling shown in the examples, though

they do have fine, surface cracks. The 400NEXT rail is among the rails with the least amount of RCF.

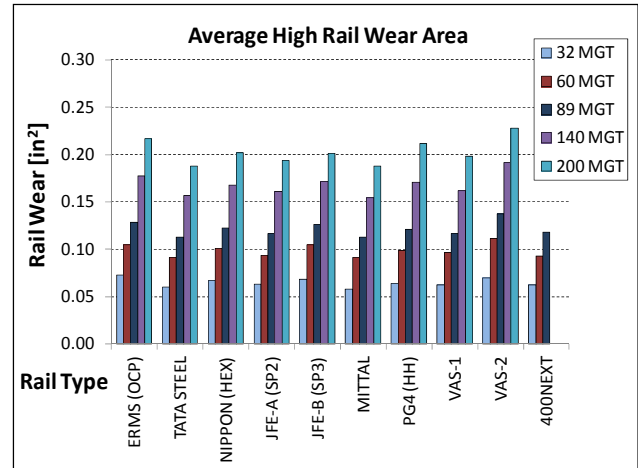


Figure 1. Area Loss (Wear) on Premium Rails after 200 MGT

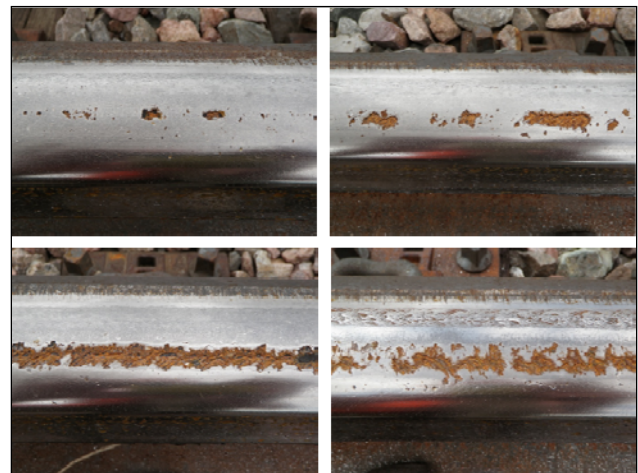


Figure 2. Examples of Degrees of Rolling Contact Fatigue in Premium Rails

Intermediate hardness (340 HB average) rails from several manufacturers were installed in a lubricated 5-degree curve and are also being tested. These rails are intended to provide acceptable performance under moderately demanding conditions, at a lower cost than premium rails. Table 2 lists the types, suppliers and head hardness of the intermediate test rails.

There is more variability in the wear rates of the intermediate rail than in the premium rail. This is probably due to the greater variation in hardness among the intermediate rails. The average wear for the intermediate rails is less than one-half that of the harder premium rails, illustrating the effectiveness of rail gage-face lubrication in reducing rail wear. Figure 3 shows rail wear (area loss) for the rails on the high rail of the curve through 200 MGT. These results are also preliminary. All intermediate rails are also showing some RCF. However, there is less RCF than in the premium rails (in the dry curve). The track geometry and operating conditions are the same for both curves. Both are 5-degree simple curves

with 4-inch superelevation, resulting in a balanced speed of about 34 mph. Average train speed of 40 mph produces a cant deficiency of about 1.6 inches. Train operations are bi-directional with approximately one-half the tonnage in each direction.

Table 2. Intermediate Hardness Test Rails

Supplier	Rail Type(s)	HB
Tata Steel (France)	MHH HE (nonhead hardened) Mill Head Hardened Hypereutectoid	325
ERMS (USA)	IH, HS, SS Intermediate Hardness High Strength, Standard Strength	334 362 321
Lucchini (Italy)	IH Intermediate Hardness	351
Mittal (USA)	ML Mittal's Grado MicoAleado AM Asturias	321
Panzhuhua (China)	PG4 (nonhead hardened)	338
Trinecké Zelezárny (Czech Republic)	TZ	328

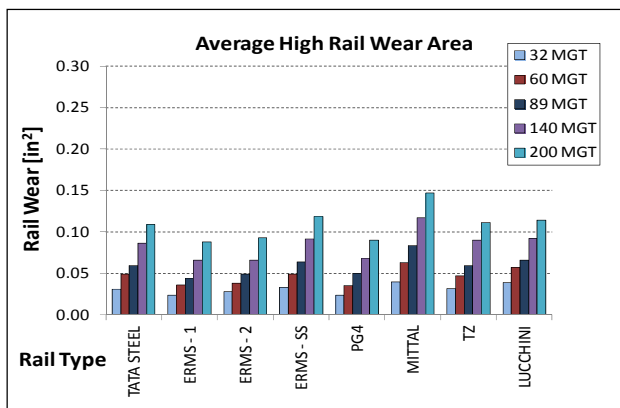


Figure 3. Area Loss (Wear) on Intermediate Hardness Rails after 200 MGT

Improved Strength Track

The trend toward heavier, faster, and longer trains will demand more and more from track structure. Passenger and freight trains may share track in increasing numbers in the future, resulting in more stringent geometry requirements. Maintenance windows will become even shorter as traffic increases. Innovative types of track structures are needed to meet these increased demands. New-design half-frame concrete ties and state-of-the-practice conventional concrete ties were installed at FAST as part of a test of improved strength track. Tie design configurations in test are half-frame ties with under-tie pads, standard ties with under-tie pads at 24-inch spacing, standard ties at 24-inch spacing, and standard ties at 20-inch spacing. The half-frame ties (Figure 4) have larger vertical and lateral footprints than conventional ties. Under-tie pads and a larger footprint both increase contact area between ballast and tie. Both are intended to reduce ballast pressure and increase track stability.

The first 315 MGT of testing shows that the half-frame tie track has provided more stable support conditions and has required less maintenance than track in the other test sections. Single-tie push tests showed that it takes more than two times

the force to push the half-frame ties laterally through the ballast compared to conventional ties. Half-frame ties have the lowest surface degradation rate while the standard ties at 24-inch spacing have the highest. Current surface degradation rates suggest that track with half-frame ties will have five times longer surface life than track with standard ties.

There are differences in ballast movement and ballast degradation between tie types. The ballast in one of the zones has shown more migration to the inside of the curve with accumulated tonnage.

More half-frame ties than conventional concrete ties have developed minor cracks. The cracks are in an unreinforced portion of the larger area under the rail seat or transverse cracks near the center of the tie. Approximately 1/3 of the half-frame ties have the transverse hairline cracks compared to 1/50 of the conventional ties. None of the half-frame ties has been removed because of the cracks. Figure 5 shows examples of both types of cracks. Study of the causes of the cracks and of their long-term effects on tie performance will continue.



Figure 4. Improved Strength Track with Half-Frame Ties

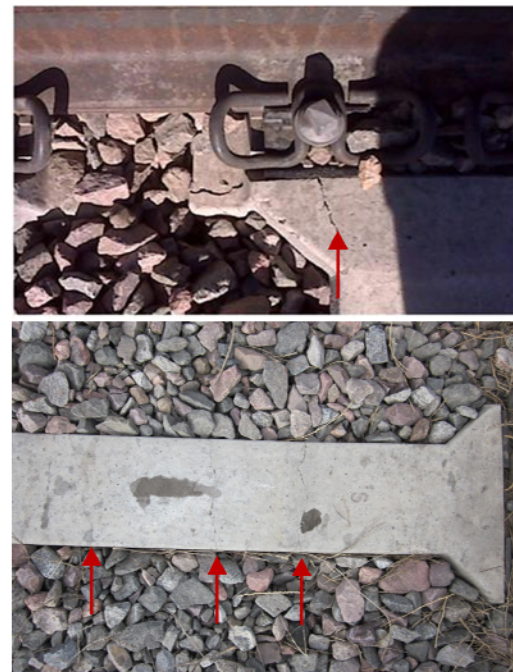


Figure 5. Cracking in Half-Frame Ties

Rail Welding Methods

Thermite railhead repair welds from Railtech Boutet and Orgo Thermit, Inc. were installed in 2009 and 2010, and electric flash railhead repair welds from the Holland Company were installed in 2011 for testing.

Ten of the thermite welds were installed over cribs, 10 were installed over electric flash-butt (EFB) welds, and 8 were installed over ties. None of the welds installed over cribs has failed in 200 MGT. Two of the welds over EFB welds have failed in 150 MGT, and two of the welds over ties have failed in 100 MGT. The welds over EFB welds failed at flashing from the thermite welds. The EFB weld makes it slightly harder to get a good fit between the molds and the rail, resulting in flashing. But, with a little extra effort, a good fit can be achieved. The welds made over ties are subject to reverse bending, putting the weld and weakest portion of the rail into tension. This is the likely cause of the increased failure rate of welds over ties.

The electric flash railhead repair welds are made by welding a wedge-shaped repair plug into the ground-out portion of the head. Eight of the welds were produced in-shop, then installed in track. None of the welds has failed in 150 MGT. Eight additional welds were installed with a mobile unit, in track. Those welds have now accumulated 40 MGT with no failures attributed to the head-repairs. One weld installed over a traditional EFB weld was removed because of a fracture in the EFB weld.

Concrete Bridges

Two concrete bridges, one a two span bridge and one with three spans, are being tested at FAST. Among the variables being evaluated are ballast condition and depth. Gradation of ballast in its new condition was compared to gradation after 489 MGT. The percentage of particles passing the No. 4 (0.19 inch) sieve increased from about 2 percent to about 18 percent.

Impact forces have also increased over time. Impact was calculated as the ratio of peak strain measured in a span at a particular train speed to the corresponding strain measured at 2 mph. Impact measured during train operations increased from about 12 percent to about 38 percent over a period of almost 400 MGT. It is theorized that as the smaller particles fill the voids in the ballast, the ballast section loses damping and performs more like a solid mass. More of the forces imparted to the rail are transmitted into the bridge structure. Fouled ballast can also reduce track strength and its ability to maintain geometry. This can lead to increased vehicle dynamics, resulting in higher impact forces. The combination of poor surface and increased transmission of forces into the structure can significantly increase dynamic forces in the bridge.

FUTURE TESTING

Tests are regularly updated at the direction of railroad committees to ensure the program meets the changing needs of the industry. Tests to be started in the next year include a continuous running surface turnout with vertical lift points and a partial flange-bearing frog, track foundations to reduce impacts at special trackwork, thermite welds produced with advanced-flow molds, and methods to reduce the heat-affected zones associated with thermite welds.

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