TECHOLOGY DIGEST

Timely Technology Transfer

TESTING AN 89-DEGREE CROSSING REBUILT WITH PREMIUM COMPONENTS UNDER HEAVY AXLE LOADS

by Joseph LoPresti, Duane E. Otter, and David D. Davis

TD 96-015

Summary

To evaluate the performance of crossing diamonds under heavy axle loads (HAL), the Association of American Railroads (AAR) tested an 89-degree crossing rebuilt with premium components. Results show that the crossing survived 15.2 million gross tons (MGT) of heavy axle load (HAL) traffic before being removed because of a broken wing rail. This crossing had been rebuilt from a previously tested standard component crossing using premium wing rail and explosion hardened castings. The original 89-degree standard component crossing survived 1.9 MGT of HAL traffic. The test was conducted as part of the Frog and Turnout Performance Experiment at the Facility for Accelerated Service Testing (FAST).

Impact forces in the crossing were measured using instrumented wheel sets under 263,000-pound and 315,000-pound cars at various speeds. The 315,000-pound car produced impacts equal to those for a 5 to 10 mph higher speed with the 263,000-pound car. The impact forces generally increase linearly with speed through 40 mph. At 40 mph, average impacts were more than three times the static wheel load for both cars.

Crossing diamond tests conducted at FAST to date seem to indicate that current designs and materials will not survive long under heavy axle loads.[1] The AAR is investigating advanced designs and materials for crossing diamonds as part of its Special Trackwork Strategic Research Initiative.

Suggested Distribution:
- ❑ Maintenance of Way
- ❑ Research and Development
- ❑ Planning and Analysis
- ❑ Bridges and Roadway

Association of American Railroads
Research and Test Department
June 1996

INTRODUCTION AND CONCLUSIONS

Annually, an estimated $22.8 million is spent replacing and maintaining nearly 4700 crossing diamonds in use on North American railroads. To evaluate the performance of crossing diamonds under heavy axle loads (HAL), the Association of American Railroads (AAR) tested an 89-degree crossing rebuilt with premium components as part of the Frog and Turnout Performance Experiment at the Facility for Accelerated Service Testing (FAST). (See Exhibit 1.) The crossing survived 15.2 million gross tons (MGT) of heavy axle load (HAL) traffic before being removed because of a broken wing rail.

Exhibit 1. Broken Wing Rail After 15.2 MGT

The broken wing rail was on the crossing route, not in traffic. This break did not interfere with FAST train operations but would have caused removal of a similar crossing in revenue service had it not been repaired. If another piece of the wing rail broke loose, there was also concern that it could end up in the flangeway.

The crossing was removed because of the broken wing rail, but other components were also failing:

- Bolts were breaking almost daily.
- Several of the beveled bolt locks had broken.
- There were cracks in the plate work.
- Batter at the crossing gaps was about 3/8-inch, and weld build-up was needed.

The original 89-degree standard component crossing survived 1.9 MGT of HAL traffic at FAST before it was removed from track.[2] The castings were then explosion hardened and reversed. Once the original wing rails were replaced with premium rail, the crossing was again installed at FAST (Exhibit 2).

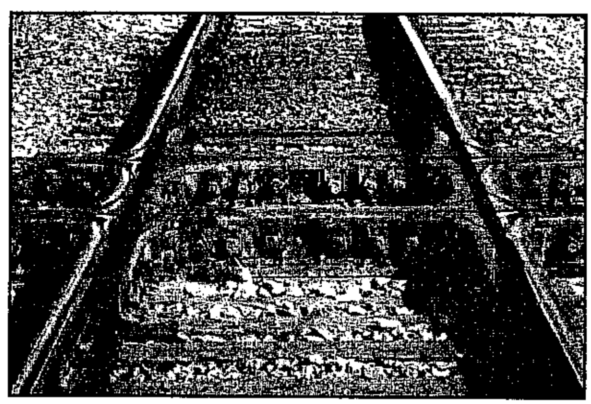

Exhibit 2. 89-Degree Crossing at FAST

Crossing diamonds affect service reliability and line capacity. High angle crossing diamonds have very short lives (e.g. 100-200 MGT) relative to conventional track or even mainline turnout frogs. Frequent crossing diamond maintenance operations require permanent or temporary slow orders, which bring disruptions to train service. Traffic bottlenecks on high tonnage lines, which are the result of crossing diamonds, can cost more than actual diamond maintenance costs.

WHEEL IMPACT FORCES

Instrumented wheel sets were used to measure impact forces in the crossing from 263,000-pound cars and 315,000-pound cars at various speeds. Exhibit 3 shows a comparison of the wheel impact forces. The 315,000-pound car produced impacts about equal to those produced by the 263,000-pound car operating 5 to 10 mph faster. At 40 mph, average impacts were more than three times the static wheel load for both cars. These impact forces are higher than tolerated by wheel impact detectors (85 to 100 kips).

Each data point in Exhibit 3 represents the average of at least 16 impact measurements. At zero speed, the static wheel loads are plotted. Measurements were taken at speeds from 10 to 40 mph in both directions. The instrumented wheel set data was sampled at a frequency of 512 Hz with 200 Hz filtering. There is also some mechanical filtering of the impact data due to the wheel mass between the strain gages and the wheel tread.

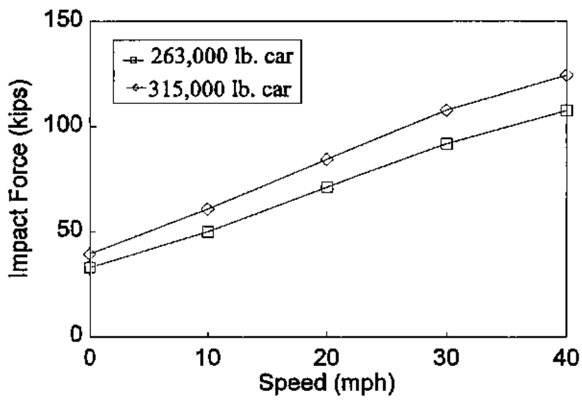

Exhibit 3. Average Impact Forces on 89-Degree Crossing

The impact forces, which generally increase linearly with speed through 40 mph, also may be a function of the amount of batter present on the crossing at the time of measurement (about 1/4-inch after 3.2 MGT).

MAINTENANCE

The following maintenance was performed on the crossing:

- The castings were ground to remove metal flow along the flangeways.
- The joints between the castings and the wing rail were slotted to remove metal flow.
- Approximately eight broken bolts were replaced.
- The crossing lost surface rapidly under the 40 mph HAL traffic and required frequent tamping.
- No build-up welding was performed.

COMPARISON

Four other crossings have been tested at FAST. Exhibit 4 shows the total HAL tonnage carried by each of the crossings before they failed. Results of the other crossing tests have been previously reported.[1]

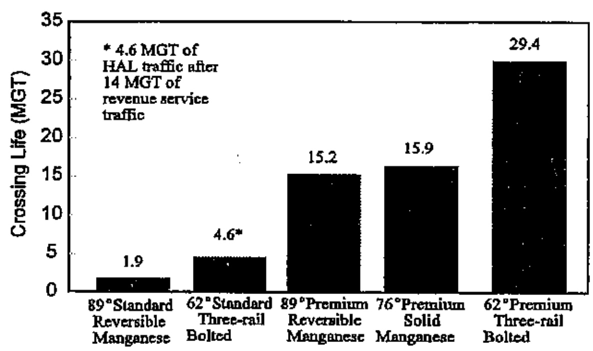

Exhibit 4. Life of Various Crossings Under HAL Traffic at FAST

CROSSING INSTALLATION AND DESIGN

The crossing was designed with the intent of the 3-degree curve route having heavier traffic than the tangent route. Ties are ordinarily laid in the direction of the heavier traffic; however, only the tangent route of the crossing could be installed, so the ties were perpendicular to the direction of traffic on the High Tonnage Loop (HTL). The diamond was placed on one 7" x 12" x 9' 0" and two new 7" x 21" x 12' 0" hardwood ties. The crossing was installed on the manufacturer's plates with cut spikes. Every tie in the section was box anchored.

Exhibit 5 shows the location of the crossing as installed at FAST.

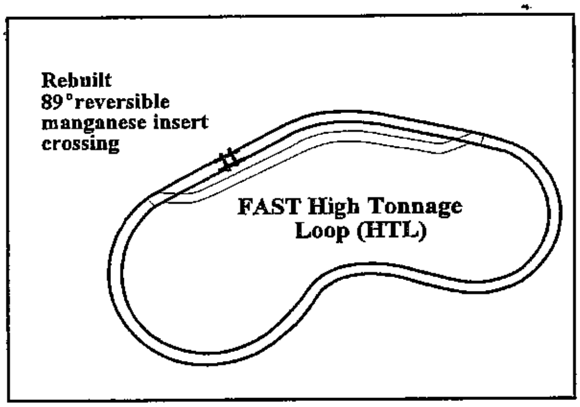

Exhibit 5. Location of 89-degree Crossing Diamond Test on the HTL

The rail surrounding the crossing was continuously welded. The ballast section had 12- to 15-inch shoulders, 2:1 slopes, and cribs full to the tops of the ties. The ballast was a mixture of granite and traprock.

Due to the track configuration at FAST, it was only possible to run trains in two of the four directions of traffic to which the diamond would normally be exposed.

89-Degree Crossing Rebuild

The crossing was rebuilt using new wing rails fabricated from NKK 133- RE head-hardened rail, with a nominal Brinell hardness number of 370. Only the wing rails in the direction of traffic were replaced. The new wing rail pieces were made by the manufacturer of the crossing, Conley Frog and Switch. The original castings were explosion hardened by the manufacturer of the castings, ABC Rail, and reversed. Casting hardness was at least 350 Brinell after explosion hardening.

The crossing was donated by the Atchison, Topeka, & Santa Fe Railway Company (ATSF). It was designed for installation at Bonner Springs, Kansas, where ATSF tangent track crossed a 3-degree curve on the Union Pacific Railroad. The crossing angle is 89 degrees, 20 minutes. The design follows AREA Plan Nos. 700F-80, 746-82 and 749-73.

ACKNOWLEDGMENTS

The authors acknowledge the assistance of the Santa Fe Railway for donating the crossing and Russell Hein of Conley Frog and Switch, and Gene Swansiger of ABC Rail for their companies' donations to the rebuilding of the 89-degree crossing.

REFERENCES

1. Otter, Duane E. and Joseph LoPresti "FAST/HAL Phase II-Crossing Diamond Tests" Volume 1: FAST/HAL Test Summaries, November 6, 1995.

2. Otter, Duane E. "Crossing Frog Test" FAST/HTL program Quarterly Progress Report No. 21, July-September 1992.