TECHNOLOGY DIGEST

Timely Technology Transfer — 02-016

Evaluation of Specialized Rail Joints for Moveable Bridges under HAL Traffic

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Summary

After accumulating approximately 54 million gross tons (MGT) of 39-ton heavy axle load (HAL) traffic at the Transportation Technology Center's Facility for Accelerated Service Testing (FAST), two-piece austenitic manganese steel (AMS) casting rail joints for moveable bridges were removed from service due to maintenance issues.

These specialized rail joints were installed for testing in September 2001 and removed March 2002. The following observations were made during that time:

- AMS casting joints were safe for 39-kip wheel load operation.
- AMS casting joints had similar dynamic vertical loads to a typical mechanical rail joint from 30 mph to 40 mph, as measured by instrumented wheelsets.
- Vertical movement of the joints caused the base-plate fasteners to fatigue.
  - Approximately two-thirds of the coach screws used to fasten the base plate to the tie worked loose or broke.
  - Some of the coach screws began to pull through the plate, enlarging and deforming the fastener holes.
  - Several of the fastener base blocks used to hold the casting/rail to the plate had broken welds.
  - Several of the elastic fasteners holding the casting to the plate failed under dynamic impact loads.
- AMS casting joints had high lateral loading, approximately 20 kips at 40 mph, on joint guards due to trucks that did not straighten out and re-center on the rails in the short tangents before the joints. The high lateral loads likely contributed to the failure of the coach screws and other components.
- Line and surface of the joints deteriorated. Once the plate to timber fasteners began to fail, the AMS casting joints began to move laterally. Steel "straps" were placed on both sides of the plates to restrain them laterally, while allowing some vertical movement.
- Vertical wheel load impacts, caused by the AMS casting joints over center pier of bridge, caused existing cracks to grow faster and several new cracks to develop during 54 MGT.
- Hook bolts used to hold ties to bridge girder had a dramatic increase on maintenance near these specialized joints.

The specialized rail joints for moveable bridges tested at FAST were comprised of two separate pieces of explosion-hardened manganese steel and were designed specifically for bascule and vertical lift bridges.

The Association of American Railroads' Strategic Research Initiatives Program sponsored this test. The AMS casting joints are being reconfigured to address the maintenance concerns and will be reinstalled this fall.

Suggested Distribution:

- ☐ Maintenance of Way
- ☐ Planning & Analysis
- ☐ Track Maintenance
- ☐ Bridge & Structures
- ☐ Safety

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INTRODUCTION AND CONCLUSIONS

Special rail joints are required at each end of the moveable bridge spans. These joints are located at the ends of the moveable bridge and allow movement of the moveable span in relation to fixed spans or non-bridge parts of the track. Dynamic loading on joints on bridge approaches often causes excessive rail end batter requiring frequent maintenance.

Previous evaluations of other types of special track work under 39-kip wheel loads at FAST have shown a significant foreshortening of service life as compared to revenue service conditions.[1] The effect is greatest at high angle frogs, where the largest impacts occur. Service life reductions of 25 to 50 percent and 50 to 90 percent were seen in low angle (turnout) frogs and in high angle crossing diamonds, respectively. These special rail joints for moveable bridges are more like low angle frogs in that, theoretically, the nominal profile wheel is always supported as it transfers from one rail to another. However, impacts do routinely occur in turnout frogs and these joints.

The objectives of this evaluation at FAST are to determine the effects of heavy axle loads on joint performance and to assist the industry in developing improved performance designs. In turnout frog tests at FAST, initial evaluations of frogs originally designed for 33-kip wheel loads have helped the industry develop improved performance designs for today's heavier axle loads. Railroads and suppliers have been able to significantly improve the performance of turnout frogs while also increasing wheel loads.

The AMS casting special bridge rail joints had a shorter life under 39-kip wheel loads than in revenue service. The joints were removed after 54 MGT due to maintenance issues.

TEST AND RESULTS

Two-piece AMS casting joints were installed and tested on the High Tonnage Loop at FAST. The joints consist of two separate pieces of explosion-hardened manganese. Each piece was fastened to a base plate with elastic fasteners. The base plate was then fastened to the ties. One side of the joint was fixed (point side), and the other side was the moveable, lift side. AMS casting joints are designed specifically for bascule and vertical lift bridges (see Exhibit 1).

The test train at FAST typically has 70 cars with 39-ton axle loads. HAL traffic occurs in two directions with the number of cycles and tonnage documented. Approximately 4 MGT of traffic ran over the joints each week. The AMS casting joints were installed in Section 5 on an open deck test bridge with two steel deck plate girders spans. The longer span is 65 feet long and 69.25 inches deep. The other span is 55 feet 6 inches long and 63 deep. The bridge lies in the middle of a 210-foot-long tangent of Section 5. There are spirals and curves at each end of Section 5.

Exhibit 1. AMS Casting Bridge Joints Installed

The joints were installed between the two spans on the bridge. The fixed side of the joints was on the large bridge span and the lift side was on the small bridge span. The two-piece AMS casting joints were installed per manufacturer specification of a 4-inch gap at the base plate.

The AMS casting joints accumulated 54 MGT before being removed for increased maintenance demands. Approximately two-thirds of the coach screws used to fasten the plate to the tie worked loose or broke. Some of the fasteners began to pull through the plate, enlarging and deforming the fastener holes. Once these fasteners began to fail, the joints began to move laterally. Steel "straps" were placed on both sides of the plate restraining the joints laterally. Exhibit 1 shows these straps. The joints were still allowed to move vertically. The elastic fasteners used to hold the casting and rail to the base plates were mounted on base blocks welded to the plates. Some of the welds and elastic fasteners failed due to the vertical movement of the joint. The plate-to-tie fasteners and the casting-to-plate fasteners did not allow for much vertical movement of the joints. Daily maintenance of tightening the coach screws decreased after the joint was restrained laterally by the straps and allowed to move vertically. Exhibit 2 shows the maintenance issues due to fasteners.

The AMS casting joints were installed without damping pads. The use of damping pads may help absorb some of the vertical impacts, decreasing the needed maintenance due to the vertical movement.

Exhibit 2. Deformed Bolt Holes and Broken Fasteners

Maintenance grinding was done at approximately 15 MGT to remove flaws from both joints. The running surface of the castings is not optimal for smooth transition between the joints. Changing the cross-sectional profile to better conform with a 1:20 taper wheel and a larger gage corner radius may allow for a smoother transition and reduce metal flow.

The AMS casting joints also contributed to increased fatigue cracking and maintenance on the bridge, due to impacts. New cracks were discovered in stiffeners in the 65-foot span near the bridge joint. Exhibit 3 shows two cracks, one between the stiffener and the top flange that extends into the weld on the web and one in the weld on the horizontal bracing angle and continuing about 4 inches through the stiffener on the back side. New cracks appeared in similar locations on two other stiffeners. Two new hairline cracks in the welds of the stiffeners to the bottom flange were discovered on the 55-foot, 6-inch span close to the center pier. These cracks were also under the bridge joint location. All of the new cracks in the spans are located under the bridge joints.

Exhibit 3. New Cracks on 65-foot Span

The hook bolts holding the deck ties in place became loose due to the vertical forces and vibrations caused by the joints. Lock plates were added to keep the hook bolts from turning off of the girder. On some of the hook bolts, the top of the bolt snapped off as shown in Exhibit 4; others snapped off at the bottom of the bolt where it was attached to the flange.

The AMS casting joints had similar vertical dynamic loads to a typical mechanical rail joint in ballasted track. Exhibit 5 shows dynamic vertical loads from instrumented wheelset data for the AMS casting joints, a typical mechanical joint, and various other components in ballasted track for comparison. The AMS casting joints had average maximum vertical dynamic loads approximately 1.5 times static wheel load. In comparison, a No. 20 turnout frog had average maximum vertical dynamic loads 2 times static wheel load, and a crossing diamond frog had average maximum vertical dynamic loads 3 times static wheel load.

Exhibit 4. Broken Hook Bolt

The AMS casting joints had higher lateral dynamic loads than a typical mechanical joint. Exhibit 6 shows average maximum lateral dynamic loads (on one rail) for the AMS casting joint and a typical open track mechanical joint. The AMS casting joint shows loads 2.5 times higher than the mechanical joint.

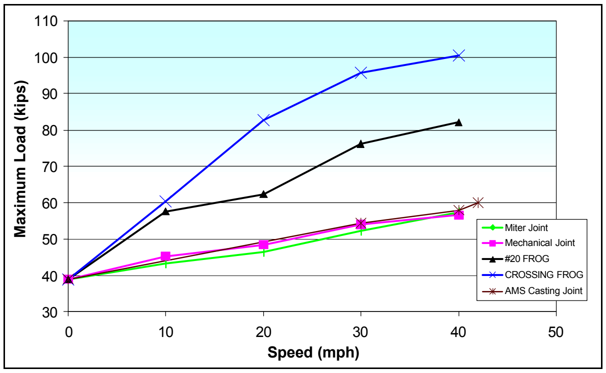

Exhibit 5. Average Maximum Vertical Dynamic Loads

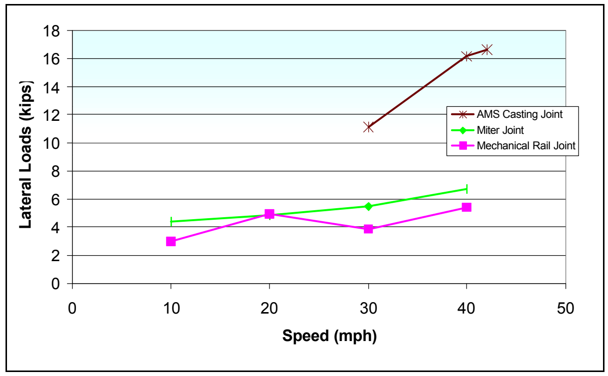

Exhibit 6. Average Maximum Lateral Dynamic Loads on the Outside (High) Rail

The bridge at FAST is located on a tangent between spirals entering 5-degree curves approximately 200 feet from the bridge joints. The joints are subject to lateral impacts from any trucks that do not straighten out and re-center themselves on the rails in the short tangents before the joints. Based on guardrail wear, a large number of wheelsets are not straight and centered at the joints. While both guards received impacts in both directions, the guard and plate work in one quadrant of the joints appeared to suffer the most damage from guard impacts. This lateral impact problem may not be an issue for tangent track locations. However, it does point to potential design and field application limitations.

The guards on the joints must be short to allow the joint to function as a lift span bridge rail joint. The 46-inch-long guards make the wheel impact angle of attack larger than it would be with turnout frog guardrails. Therefore, it is problematic to improve upon the design. A remedy may be to locate guardrails just before the joints.

FUTURE WORK

The AMS casting bridge joints are being reconfigured for better dynamic performance. The plate work and fastening systems are being reconfigured to allow for vertical movement and to decrease the required maintenance. The bridge joints will be re-installed and further evaluated in the fall.

REFERENCE

1. Davis, D., D. Guillen, S. Singh, J. Robeda and J. LoPresti, “Results from Special Track Work Experiment at FAST,” Research Report R-954, AAR/TTCI, February 2002.

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