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Performance of Two Concrete Bridges at the Facility for Accelerated Service Testing for 500 MGT

SUMMARY

Two new precast concrete bridges were installed by the Transportation Technology Center, Inc. (TTCI), a wholly owned subsidiary of the Association of American Railroads (AAR), Pueblo, Colorado, at the Facility for Accelerated Service Testing (FAST) in December 2003. The bridges have accumulated 517 million gross tons (MGT) of 315,000-pound gross rail load traffic (GRL). A variety of long- and short-term tests are underway. Ongoing testing is funded by AAR and Federal Railroad Administration.

To date, the concrete box girder spans have performed well with a structural strength under 315,000-pound GRL traffic.

In-field repairs (prior to installation) of girder-end damage have performed well, with no deterioration of the repaired areas noted by TTCI to date.

Deterioration of the concrete bridges thus far at FAST includes cracking in ballast curbs, wear at lateral restrainers, an end corner crack near a bearing pad, and bent and broken anchor bolts near lateral restrainers.

These concrete bridges on a 5-degree curve provide a challenging environment for track ties and fasteners, with significant degradation noted in less than 300 MGT, including broken ties, broken tie plates, and loose screw spikes.

Concrete bridges are the most commonly constructed railroad bridges in recent years. They are typically the preferred replacement for timber trestles. Because of the significant investment being made in concrete bridges, it is prudent to understand their response to heavy axle load traffic.

Figure 1. Conventional Concrete Bridge (left) and State-of-the-Art Concrete Bridge (right) at FAST.

BACKGROUND

With the increasing use of concrete bridges to replace timber bridges on HAL corridors, it is important to understand their performance. Two new concrete bridges were installed at FAST in December 2003. A variety of tests are being conducted by TTCI under 315,000-GRL traffic, many of which have been reported previously [Ref. 1,2,3]. This report summarizes the general performance of these bridges to date. Figure 1 shows the state-of-the-art (SOA) and conventional concrete bridges installed by TTCI at FAST.

One bridge features three SOA spans, including a 15-foot slab span, a 42-foot-high performance concrete double voided box girder, and a 30-foot double voided box girder. The 15-foot slab and 30-foot box girder spans were donated by the Union Pacific (UP). They were designed to the new UP/BNSF Railway (BNSF) joint standards, including the current American Railway Engineering and Maintenance-of-Way Association Cooper E-80 design load. The 42-foot-high performance span was designed and donated by Canadian National, featuring a concrete strength of 9,000 pounds per square inch (psi), and a Cooper E-90 design load.

The second bridge features two conventional spans, of 24- and 32-foot lengths. These spans were originally cast in 2001 to the BNSF standards at that time, with a Cooper E-80 design load. They were donated by Rinker Materials (now Coreslab).

Tests underway include measurements of strains, impacts in spans and foundations, and the effects of tie types on both bridge impacts and track surface maintenance. Long-term performance evaluations include performance of the spans under HALs, field repairs to spans, and durability of water proofing materials.

To date, the spans have performed well from a structural standpoint. Deterioration and maintenance issues for the bridges themselves have been noted, but not critical in nature. Since being placed in service, no repairs have been necessary.

The bridges provide a challenging environment for track ties. The ties and fasteners have experienced damage requiring repair or replacement in less than 300 MGT. In addition, the track on and near the concrete bridges has required tamping more frequently than open track.

GIRDER IN-FIELD REPAIRS

Both of the 30-foot concrete box girders were damaged during transport from the precasting plant to FAST. The damage was mainly at the girder ends (Figures 2 and 3). The concrete was repaired using Sikadur High Mod 33 (two-part epoxy) mixed with dried masonry sand. This is considered a 10,000 psi grout. The repair was then covered with a skim coat of Hilti RM800. The repairs were performed in the field at FAST by the manufacturer before the girders were installed in the bridge (Figures 4 and 5). After 517 MGT of 315,000-pound GRL traffic, no chipping or spalling is evident in the repaired areas.

Figure 2. Damaged Concrete Box Girder A (left) before Repair. Figure 3. Damaged Concrete Box Girder B (right) before Repair.

Figure 4 (left). Repaired Concrete Box Girder A. Figure 5 (right). Box Girder B.

CRACKS IN CONCRETE BRIDGE SPANS

Cracks initiated from several of the deck drain openings and propagated in ballast curbs (Figure 6). The ballast curbs were cast separately at the plant after the box girders were removed from the prestressing bed. The curbs are cast with asphalt separation panels along their length to minimize the amount of live load they carry. The asphalt panels are centered at the drain opening locations. Since the ballast curbs are not a structural part of the main girder, the cracks do not seem to pose any problems at this point. Figure 7 shows the largest of these cracks.

Figure 6. Typical Cracking near Deck Drain Opening (left). Figure 7. Largest Crack near Deck Drain Opening (right).

Figure 8 shows a bearing pad on one span at the center pier of the conventional bridge that worked its way out from under the girder. To restrict movement, this pad was glued to the top of the pile cap. Shortly thereafter, a crack was observed at the girder corner nearest that pad, as Figure 9 shows.

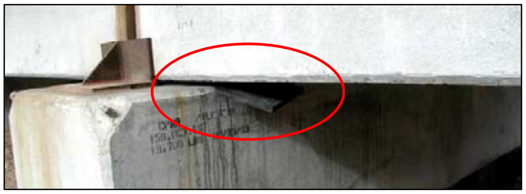

Figure 8. Bearing Pad Working out from Concrete Span.

Figure 9. Cracked Girder Corner after Bearing Pad was Glued in Place.

Figure 10 shows bent and broken anchor bolts on the 42-foot span of the SOA bridge. The span has moved outward slightly on the 5-degree curve.

Figure 10. Bent and Broken Anchor Bolts on SOA Bridge.

During a normal track surfacing operation, a regulator struck the ballast curb at the southwest corner of the conventional concrete bridge. This appears to have caused a crack in the curb. Figure 11 shows the ballast curb crack.

Figure 11. Ballast Curb Crack.

PERFORMANCE OF TIES ON CONCRETE BRIDGES

These concrete bridges on a 5-degree curve provide a challenging environment for track ties and fasteners, with significant degradation noted in less than 300 MGT. Normal train operation at FAST is 40 miles per hour (mph), compared to a balanced speed of 34 mph over the concrete bridges. The bridges have 4 inches of superelevation on the High Tonnage Loop at FAST. The bridge decks have 12 inches of granite ballast beneath the low rail of the ties and 16 inches of granite ballast beneath the high rail.

PLASTIC COMPOSITE TIES

The SOA bridge had 57 plastic composite ties installed on top of it. These ties have accumulated about 179 MGT of traffic. The ties were manufactured by Tie-Tek and donated by UP.

A total of 10 plastic ties cracked on the SOA bridge. On the outside (high) rail, there were nine cracked or broken ties. On the inside (low) rail, there were three broken or cracked ties. Two ties were cracked under both rails. There were two broken tie plates on the outside rail and two broken tie plates on the inside rail. Also, three ties on the outside rail had screw spikes that loosened significantly. All of the cracks pass through the holes for the screw spikes. Figures 12 and 13 show plastic composite tie cracks and a broken tie plate on the SOA bridge.

Figure 12. Cracked Composite Tie with a Loose Screw Spike.

Figure 13. Broken Tie Plate on Cracked Plastic Composite Tie.

TIMBER TIES

Thirty-six timber ties (oak) on the conventional bridge accumulated 335 MGT of 315,000-pound GRL traffic. Some ties became slightly skewed so that the rail is wearing into the inside of the curved part of the Pandrol plate causing a crack. Figure 14 shows a cracked Pandrol plate with a loose screw spike on the high rail of the conventional bridge. This wearing caused the cracking of 12 tie plates, all on the high rail. Four of the plates were side by side. All 12 plates were replaced. Two of the plates had the screw spikes broken off. Others had loose screw spikes. A cut spike was used to hold each plate temporarily. Similar problems have been noted in the tie and fastener experiment at FAST [Ref. 4].

Figure 14. Cracked Pandrol Plate with a Loose Screw Spike.

CONCRETE TIES WITH RUBBER PAD BOTTOMS

Two generations of UP prestressed concrete ties with rubber pads attached to the bottoms installed on the SOA bridge accumulated over 100 MGT each. The first generation ties featured rubber pads glued to the bottoms. After 130 MGT, the rubber showed no signs of wear, but the pads became partially unglued on some ties (Figure 15). The second generation ties featured rubber pads cast into the bottoms. After 155 MGT, some deterioration of the interface was evident near the edges (Figure 16).

Figure 15. Concrete Ties with Glued and Unglued Rubber Pads.

Figure 16. Concrete Ties with Cast-In Rubber Pads.

TRAIN OPERATIONS AT FAST

The FAST train normally has no flat wheels. Other than a brief (19 MGT) bolted rail joint test on the 15 foot span, there have been no bolted rail joints on the concrete bridges. The primary impacts are mostly of low frequency mainly caused by vehicle dynamics, such as car bouncing and rocking effects. Concrete bridges in revenue service can be expected to experience all of these types of impacts, as well as a greater variety of train speeds.

REFERENCES

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