TECHNOLOGY DIGEST

Timely Technology Transfer — 98-030

CRACKS IN WELDED GIRDERS OF THE FAST BRIDGE

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Summary

One of the spans used to construct a new bridge at the Facility for Accelerated Service Testing (FAST) has developed numerous cracks in the first 114 million gross tons of heavy-axle-load (HAL) train operation. This indicates that as loads are increased in revenue service, particular care should be given to regularly inspect welded-steel bridges, particularly those with details known to be poor, for crack initiation and growth. The two-span bridge was installed in Section 5 of the High Tonnage Loop for purposes of evaluating issues related to railway bridge decks and approaches. Transportation Technology Center, Inc., staff have noted the following results since installation of the FAST bridge at the Federal Railroad Administration's (FRA) Transportation Technology Center in November 1997:

- Several cracks developed in both girders of the 65-foot welded-steel span. Some cracks were visible after only a few weeks of HAL-train operations.
- After only 82 MGT of HAL traffic, a helper crib was installed beneath the 65-foot span because a large crack propogated into the tension flange of one girder.
- A combination of hole drilling and the helper crib has halted the growth of some cracks.
- New cracks continue to be noted and are growing.
- No cracks have yet been noted in the girders of the 56-foot span, which has a different weld detail for the intermediate stiffeners.

The poor weld detail where most of the cracks initiated is no longer acceptable under practices currently recommended by the American Railway Engineering and Maintenance of Way Association. However, there may be some welded-steel spans in service which have these poor details.[1] As HAL traffic increases, these spans are more likely to develop cracks. They should be evaluated for inspection on an accelerated basis so that appropriate action may be taken in case cracking occurs. This study was partially funded by the FRA.

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INTRODUCTION AND CONCLUSIONS

One of the spans of the steel deck-plate-girder (DPG) bridge at the Facility for Accelerated Service Testing (FAST) has developed cracks while accumulating 114 million gross tons (MGT) of heavy-axle-load (HAL) operation. The two-span bridge was installed in Section 5 of the High Tonnage Loop for purposes of evaluating issues related to railway bridge decks and approaches. The bridge was opened to traffic in November 1997, and carried a total of 114 MGT of heavy-axle-load (HAL) traffic prior to the summer of 1998. Cracks developed in both girders of the 65-foot welded-steel span shortly after opening the bridge to traffic. Many of the cracks were arrested by drilling holes at the ends of the cracks. By 82 MGT, one of the cracks propogated into the tension flange of a girder, requiring installation of a helper crib beneath that span. All cracks appear to have initiated at welds with poor details. As HAL traffic is introduced in revenue service, particular care should be given to schedule inspection on welded-steel bridges with poor details.

CRACKS IN GIRDERS

Exhibit 1 shows the crack propogating through the flange-to-web weld and into the tension flange of the girder. The crack is nearly 7 inches long. A ⅞-inch hole was drilled at the top of the crack to stop crack growth in the upward direction. The crack was first detected during a bridge inspection after 37 MGT of HAL traffic. The hole was drilled at that time. During an inspection after 55 MGT of traffic, crack propogation into the tension flange was not yet noted. During inspection after 82 MGT, it was noted that the crack ran completely through the weld and into the tension flange. At that point, the crack in the tension flange was about 4½ inches long and up to 3/16 inch deep. It appears that this crack initiated near the area where the flange-to-web weld and the web-to-stiffener weld intersect. This crack is near intermediate stiffener No. 6 on this girder. Intermediate stiffener No. 7 is at midspan.

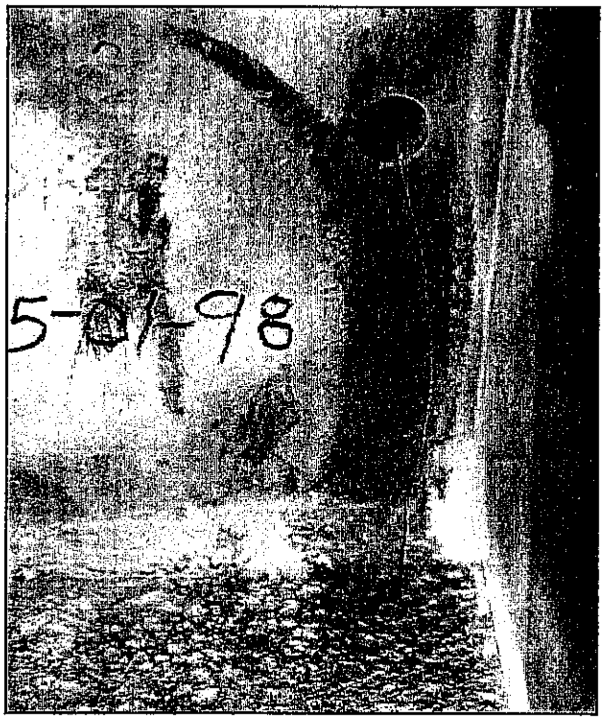

Exhibit 1. Crack Propogating into Tension Flange of Welded Girder

Exhibit 2 shows the helper crib that was constructed to support the 65-foot DPG span beneath intermediate stiffeners Nos. 6 and 7. The crib was constructed using steel H-piles. As settlement occurs, shims are added as necessary.

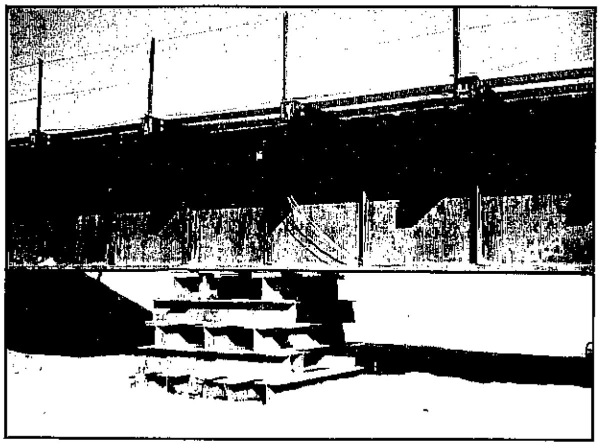

Exhibit 2. Helper Crib Supporting Cracked Span

Exhibit 3 shows the crack near intermediate stiffener No. 7 in the same girder. This crack is very typical. Several similar cracks have been found in both girders of this span. The cracks appear to initiate in the area where the flange-to-web weld and the web-to-stiffener weld intersect. This particular crack has been drilled at both ends with ⅞-inch diameter holes. So far no growth has been noticed in any of the cracks that have been drilled. Some of the smaller cracks which are not yet big enough to drill properly have continued to grow. These cracks have been noted at intermediate stiffeners that have bracing attached as well as at those with no bracing.

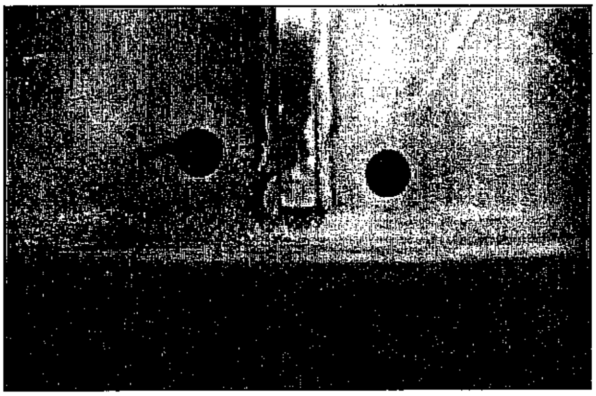

Exhibit 3. Typical Crack in 65-Foot Welded-Steel Bridge Girder with Poor Weld Detail

FATIGUE-PRONE WELD DETAILS

All girders in both spans are welded fabrication, including bracing members. This type of fabrication is very stiff compared to bolted or riveted construction. The span which cracked is one of the earliest welded-steel railway bridge spans. It was designed in 1956 for a Cooper E-72 loading with diesel impact. For comparison, the HAL train is equivalent to about an E-56 loading on this span. The intermediate stiffeners were designed to allow ¾-inch clearance from the bottom of the stiffener to the top of the tension flange. The intermediate stiffeners are 7 x ¾-inch plates. The web is ⅝-inch plate, and the tension flange is 2⅝ inches thick by 18 inches wide. The flange-to-web weld is ½ inch. The web-to-stiffener weld is 5⁄16 inch and wraps around the end of the stiffener. Due to the small amount of clearance and the weld wrapping around the ends of the stiffeners, the stiffener weld overlaps with the bottom flange weld, as can be seen in Exhibit 3. This area is where most of the cracks appear to have initiated. Current American Railway Engineering and Maintenance of Way Association (AREMA) recommended practice calls for a distance of four to six times the web thickness between welds, which would be 2½ to 3¾ inches for this span.

The 56-foot span was designed in 1967 for a Cooper E-72 loading with diesel impact. The HAL train is equivalent to about an E-61 loading on this span. The intermediate stiffeners were designed to allow 1-inch clearance from the bottom of the stiffener to the top of the tension flange. The intermediate stiffeners are 6½ x ½-inch plates, the web is ½-inch plate, and the tension flange is 2½ inches thick by 14 inches wide. The flange-to-web weld is ½ inch. The web-to-stiffener weld is 5⁄16 inch, and does not wrap around the end of the stiffener. Exhibit 4 shows this detail. There is about ½ inch of space between welds in this span. Although this detail still does not meet current AREMA-recommended practice, no cracks have been noted to date in this span. The actual distance between welds is one web

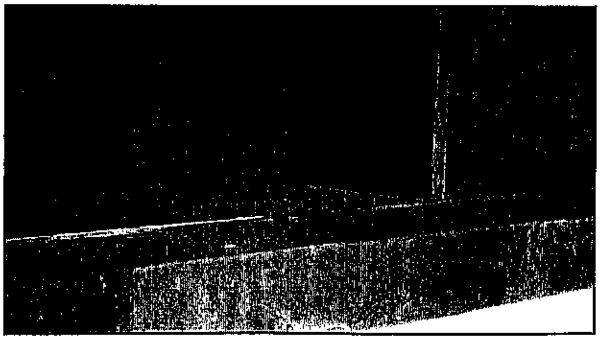

Exhibit 4. Stiffener Weld Detail in 56-Foot Span

thickness, as opposed to the four to six times the web thickness that is recommended. The fact that there is some separation rather than overlap between welds might be one reason that no cracks have been noted so far. The thinner stiffeners might also be a factor.

TRAFFIC HISTORY

Prior to their installation at FAST, these DPG spans carried very little tonnage. It is likely that the 56-foot span carried less than 5 MGT total, and the 65-foot span less than 10 MGT total. The traffic most likely consisted of 70-ton cars (220,000 pounds gross rail load) or lighter.

The load environment at FAST is particularly severe, consisting of primarily HAL cars with 315,000-pound gross rail load. All tonnage is due to the fully loaded FAST train, whereas in revenue service, there is often mixed-freight traffic and empty trains as well. The vertical wheel load environment is summarized in Exhibit 5. Certainly the heavy load environment is responsible in part for the cracking of the 65-foot span.

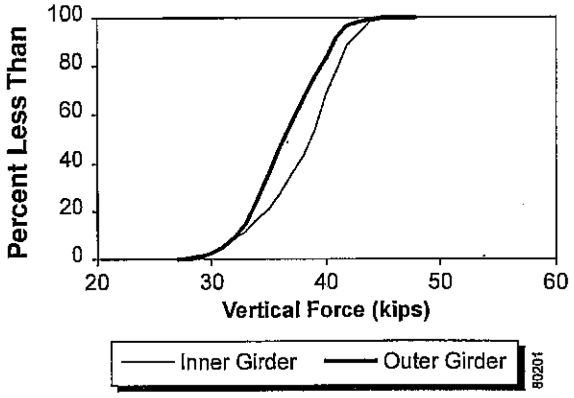

Exhibit 5. Vertical Wheel Load Environment at FAST

BACKGROUND

The FAST bridge was installed during summer and fall of 1997. The first train operations over the bridge were in November. The second-hand steel deck-plate-girder spans were donated by Conrail. The pile driving was donated by Union Pacific. The precast concrete foundation elements were donated by Wilson Concrete. Assistance with general construction was donated by Burlington Northern Santa Fe. The bridge has two open-deck spans. New timber deck ties were installed per Conrail specifications. Continously welded 136-pounds-per-yard rail was installed on the bridge and approaches.

ACKNOWLEDGMENTS

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REFERENCE

"Fatigue Strength of Steel Beams with Welded Stiffeners and Attachments," Fisher, J.W.; Albrecht, P.; Yen, B.T.; Klingerman, D.J.; McNamee, B.M.; NCHRP Report 147.

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