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# Bracing and Lateral Deflections: Vintage Steel Bridge Span at the Facility for Accelerated Service Testing

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**Summary**

In an effort to extend the life of railroad bridges and to develop recommended practices for life extension maintenance and cost effective repair procedures, Transportation Technology Center, Inc. (TTCI) installed a 1912 vintage steel deck plate girder bridge span in the steel bridge at the Facility for Accelerated Service Testing (FAST) in December 2009.

Observations from the lateral bracing tests and from additional monitoring are summarized below:

- Installation of bracing repairs limited the maximum lateral deflection of the bridge span.
- Corrosion of gusset plates and connecting bracing are a concern for older steel bridges. Various repair and replacement techniques are being evaluated on this span.
- Most of the corrosion is in or near horizontal gusset plates, where moisture did not drain quickly. The vertical gusset plates show comparatively little corrosion.
- Heavy axle load (HAL) traffic can have detrimental effects on secondary members, requiring three repairs in the first 100 million gross tons (MGT) at FAST.
- The simple bolted splice repairs made on the span have performed well so far (over 200 MGT).
- The vintage span has withstood over 200 MGT of HAL traffic at FAST.

Lateral bracing results on this span show somewhat higher lateral deflections in comparison to results from tests conducted on three bridges on the Canadian National Railway.[1]

The original 55-foot 6-inch welded girder in the east span of the steel bridge at FAST was replaced with a 55-foot-5-inch riveted girder span. The 1912 span was originally built by the Wabash Railroad to cross Wildcat Creek near Lafayette, Indiana. The span was donated by Norfolk Southern Railway.

By installing the 1912 vintage span at FAST, observations and testing can be performed in a controlled environment under HAL traffic. Performance observations and test information will provide a good insight on where and when these bridges will require maintenance.

The vintage span is being monitored for performance under HAL traffic, including deterioration and maintenance requirements for bridge components. As deterioration is found through frequent inspections, repairs are made as necessary. Lateral bracing tests were performed on the bridge to compare span performance before and after repairs were made.

This study was conducted by TTCI as part of the Association of American Railroads' Strategic Research Initiatives Program.

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TTCI. Transportation Technology Center, Inc.

## INTRODUCTION AND CONCLUSIONS

Thousands of riveted steel girder railway bridges are still in service in North America. Many are approximately a century old. While they have performed well thus far, there is concern about their sustained performance under HAL traffic.

By installing the 1912 vintage span at FAST, observations and testing can be performed in a controlled environment under HAL traffic. Performance observations and test information will provide a good insight on where and when these bridges will require maintenance.

Along with frequent inspections, the vintage span at FAST underwent lateral bracing tests before and after initial repairs were made. Repair of the lateral bracing system helped limit lateral deflections of the girder under HAL traffic.

## BRIDGE DESCRIPTION

The 1912 vintage span at FAST is a riveted 55-foot 5-inch steel bridge span. At FAST the span has been subjected to about 200 MGT of traffic under the HAL train, which is made up of 315,000-pound gross rail load cars. Note that the HAL train at FAST typically runs at 40 mph and does not include cars that generate significant wheel impact loads.

## INITIAL REPAIRS

Before the vintage span could be installed in the steel bridge at FAST, an initial inspection was made. Several repairs were needed before installing the span. Figure 1 shows the areas where initial repairs were made to the top lateral bracing system.

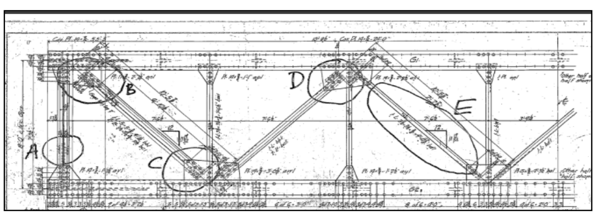


**Figure 1. Plan View of Vintage Span Repair Areas**

At Location A, the horizontal cross members were rusted all the way through. To correct this, the angles were replaced with the same size angle. Bolted connections were used instead of rivets. Figures 2a and 2b show the rusted horizontal member.

Rusted gusset plates at locations B and C were replaced. Lateral bracing members on both ends of the bridge had broken off. The lateral braces were left off until baseline data was collected.

At Location D, the gusset plate and rivets were rusted through. Also, the rusted lateral brace was unattached. The gusset plate was replaced and prepared for a bolted connection for a brace after baseline data was collected.

**Figure 2a. Pre-existing Rusted Member**

**Figure 2b. Pre-existing Rusted Member**

Location E completely lacked a lateral bracing member. The gusset plate was prepared for a new member to be installed after baseline data was collected.

## CRACKS AND REPAIRS

After 72 MGT of traffic at FAST a broken bracing member was found on the vintage span. The brace was a bottom lateral angle at mid-span. It broke at the gusset plate connection to the bottom flange of the south girder. The horizontal leg of the angle, which connected to the gusset plate, was rusted through most of its cross section. There appeared to be about a 1/2-inch crack growth region near the corner of the angle. The vertical leg was fractured resulting in a pull-apart gap of about 3/16 inch. Horizontal displacement was also about 3/16 inch. Vertical displacement was about 1 inch, which was primarily due to the dead weight of the member (see Figure 3a).

The train ran one night (109 train passes) before the brace was repaired. No additional damage was noted. The repair made was a simple splice of the vertical leg of the angle (Figure 3b).

**Figure 3a. Broken Member**

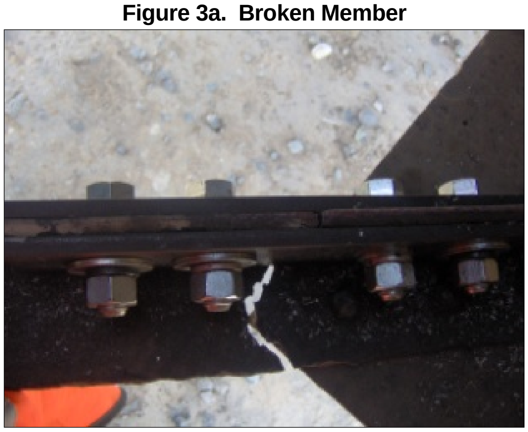

**Figure 3b. Splice Repair**

After 83 MGT of traffic at FAST, another broken bracing member on the vintage span was found. The brace was a top cross frame member at the east intermediate diaphragm. It broke at the gusset plate connection to the top flange of the south girder. Figure 4a shows the horizontal leg of the angle, which connected to the gusset plate, was rusted through for most of its length. The train ran one night (127 train passes) before the brace was repaired (Figure 4b). No additional damage was noted. The repair was once again a simple splice of the vertical leg of the angle.

**Figure 4a. Cracked Lateral Bracing Member**

**Figure 4b. Splice Repair to Vertical Leg of Cross Frame Member**

After approximately 100 MGT, a splice repair was made to a top lateral brace. The horizontal leg of the brace was mostly corroded, with a crack beginning from the corrosion. The crack propagated about 2 inches into the vertical leg before repair, leaving only about 1 inch of the cross section remaining. Figure 5 shows the repair to the vertical leg.

**Figure 5. Splice Repair to Vertical Leg of Top Lateral Brace**

## LATERAL BRACING TEST

In March 2010, lateral tests were performed on the vintage span. Previous work regarding lateral bracing and lateral forces on bridges has been performed by Canadian National (CN) Railway and at FAST.[1,2,3] Two reference frames were fabricated and installed near mid-span outside of both the north and south girders. String potentiometers were attached to the top flange as well as the bottom flange to monitor the lateral deflections of the girders during dynamic testing. String potentiometers located on the bottom of each girder at mid-span were used to measure vertical deflections. These lateral tests were performed before repairs were done and again after repairs were installed. Test runs were made using different train speeds from 5 to 45 mph. This allowed comparisons to be made in measured lateral deflections.

Figures 6a and 6b show the top flange lateral deflections of the north and south girders before and after repairs to the lateral bracing. As expected, the amount of deflection increased with increase in train speed. Note that the bracing limits the amount of lateral deflection. Without the bracing repairs, the maximum lateral deflections were over 30 percent higher under the HAL train (Figure 7).

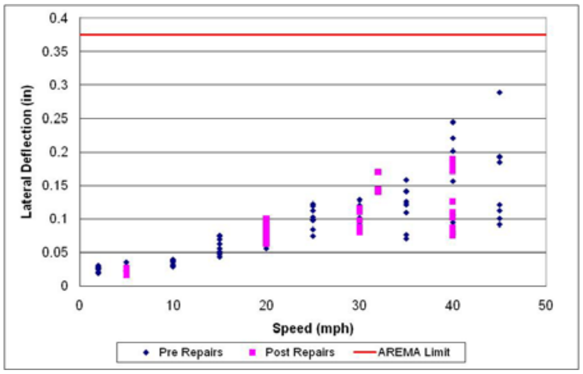


**Figure 6a. North Girder**

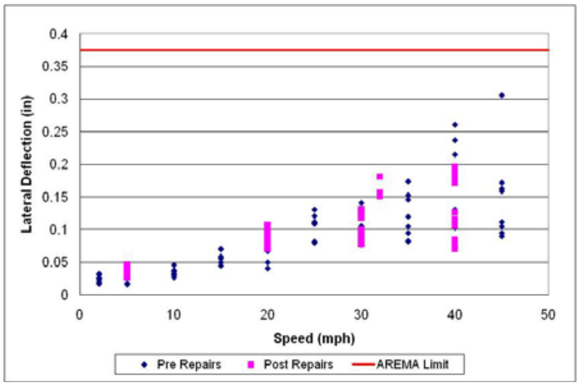


**Figure 6b. South Girder**

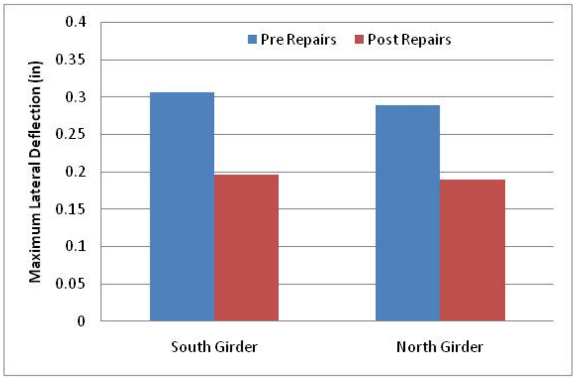


**Figure 7. Maximum Lateral Deflection Pre- versus Post-Repairs**

Both the north and south girder measurements for lateral deflection are within the American Railway Engineering and Maintenance-of-Way Association limit of 3/8 inch.[4] The results for lateral deflection show higher deflections than those measured on three CN steel bridges[1] despite the lateral bracing that had been repaired. The train at FAST has heavier cars, and the post-repair data was collected under the entire train of more than 100 cars. The CN data was collected at higher train speeds. A short test train was used for the CN tests.

The vertical deflection measurements were the same before and after repairs.

## FUTURE CONCERNS

The vintage span is still undergoing observation and testing. Concerns under observation include:

- 1 cracked top lateral brace
- 2 top gusset plates with corrosion and cracking
- 2 bottom lateral members with buckling concerns

A moveable bridge joint has recently been installed at one end of the vintage span. The increased impact loading from the joint and its effects on the bridge spans will be closely monitored to observe any changes in bridge condition and maintenance needs.

## REFERENCES

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2. Muhammad N. Akhtar, Duane Otter, and Brian Doe. May 2006. "Stress-State Evaluation of Lateral Braces in Open Deck Steel Girder Bridge at FAST." *Technology Digest* TD-06-013. Association of American Railroads, Transportation Technology Center, Inc., Pueblo, Colorado.

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4. American Railway Engineering and Maintenance-of-Way Association. 2010. *Manual for Railway Engineering*. Chapter 15, Lanham, Maryland.