

EFFECTIVENESS OF HELPER STRINGERS IN STRENGTHENING TIMBER BRIDGES

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Summary

Helper stringers have proven effective in strengthening open-deck timber bridges in tests conducted by the Association of American Railroads (AAR) on two separate bridges. One of the bridges is located on a Transportation Technology Center access track in southern Colorado. The other bridge is located on a Union Pacific (former Southern Pacific) line in southwestern Texas. The helper stringers were installed using both outboard stringers and re-centered chord techniques for these tests, which were conducted as part of AAR's Timber Bridge Life Extension Program.

The bridges are different with regards to construction details, age, amount of traffic, tonnage characteristics and weather exposure. As such, the emphasis of this digest is to present test results from both strengthening techniques and not to compare methodologies of installing helper stringers. Based on the initial results, the following conclusions can be made:

- In the case of the UP bridge, the helper stringer reduced the average chord deflections.
- In both cases, the helper stringer contributed significantly to load sharing.
- Although the helper stringer contributes to the load sharing, it did not help the chord act as a unit.

The purpose of these tests was to use load-path information to determine the effectiveness of installing helper stringers in two configurations: using both outboard stringers and re-centered chord techniques. In the case of the bridge in Texas, data was obtained from revenue-service trains and a test train operating at various speeds. The timber bridge in Colorado was tested using a test train only. Because the substructure components (piles, caps, bents) for all the test bridges were in good structural condition and free of rot, substructure strengthening was not required. Results from these strengthening techniques could vary on bridges with different traffic types, tonnage characteristics, bridge deck-fastening systems, design details, rail sizes and maintenance procedures. The long-term performance of these strengthening techniques has not been quantified.



Suggested Distribution:

- Bridges and Roadway
- Maintenance of Way
- Maintenance Planning
- Structures

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INTRODUCTION AND CONCLUSIONS

In an effort to develop cost-effective techniques for strengthening and/or extending the life of existing timber bridges, the Association of American Railroads (AAR) tested two timber bridges in the fall of 1996 and spring of 1997. The bridge in southern Colorado is located at Avondale. The bridge in southwestern Texas is located near the town of D'Hanis. The Avondale bridge was previously tested using the AAR's Track Loading Vehicle (TLV) in the summer of 1995 in order to determine load path and behavior characteristics. After a detailed "as-is" analysis, the bridge was strengthened with a solid-sawn helper stringer in the winter of 1996. The helper stringers were added to the outside of the existing stringers in each chord. The chord was not re-centered after the helper stringer installation. The bridge does not carry considerable amounts of traffic. Before its strengthening, it had a Cooper rating of E 45. A Burlington Northern Santa Fe bridge crew performed the strengthening work.

The bridge at D'Hanis was selected for a variety of tests in 1996 because of its unique feature — the south chord is comprised of four solid-sawn stringers while the north chord contains four glued laminated stringers. Testing on this bridge was used to analyze several strengthening techniques including the use of helper stringers and the use of glued laminated components. This digest will report on only the helper stringer testing (refer to the Technology Digest entitled "Effectiveness of Glued Laminated Components in Strengthening Timber Bridges, TD 97-026" for other test results from this bridge).

Solid-sawn helper stringers were installed on four adjacent spans on the solid-sawn chord at the eastern end of the bridge and the remainder of the solid-sawn chord was left alone. For the spans containing a helper stringer, the chord was re-centered. Hence, each passing train provided readings of the chord with and without the helper stringer which provided more of a side-by-side comparison (as opposed to a before-and-after comparison) of the helper-stringer performance. This bridge is located on a main east-west route of the Union Pacific (UP) (former SP) and carries heavy-axle-load traffic.

Results from both tests indicate that the helper-stringer contributes significantly to the load sharing and reduces the amount of stringer deflection.

BRIDGE DESCRIPTIONS

The configurations of the two open-deck bridges prior to strengthening are similar. Exhibit 1 illustrates the cross section of the D'Hanis bridge. In this case, the chord was centered. The primary difference in the Avondale bridge is that the chord was not re-centered after the installation of the helper stringer. Also, the Avondale bridge had helper stringers added to both chords.

The substructure of the D'Hanis bridge is composed of 14-inch square caps supported by six pile bents at the intermediate supports and five pile bents at the abutments. Nominal bent spacing is 15 feet center-to-center. The bridge has 12 spans. The superstructure consists of two longitudinal packed chords, each containing four stringers (prior to the helper-stringer installation). The stringers in the south chord were installed in 1989 and are solid sawn measuring 7.75 inches wide by 16.25 inches deep. The glued laminated stringers on the northern chord were installed in 1990 and are deeper, measuring 6.75 inches wide by 18 inches deep. The solid-sawn helper stringer measures 7.75 inches wide by 17.25 inches deep. The helper stringers were notched over the supports prior to installation. The majority of the stringers were 30 feet in length and continuous over two spans. Individual stringers were bolted together with 0.75-inch-diameter bolts near bearings and at midspan for lateral stability only (not intended to promote load sharing between stringers). The rail is 136 lb/yd continuous-welded rail. The bridge ties are 10 inches wide by 8 inches deep by 8 feet long. Tie spacing is 18 inches center to center. The ties were in good condition. The D'Hanis bridge was originally constructed of creosote-treated Douglas fir-larch in 1937.

The Avondale bridge is a three-span, open-deck bridge located on the west wye track in Avondale, Colorado. The bridge is about 42 feet in length and

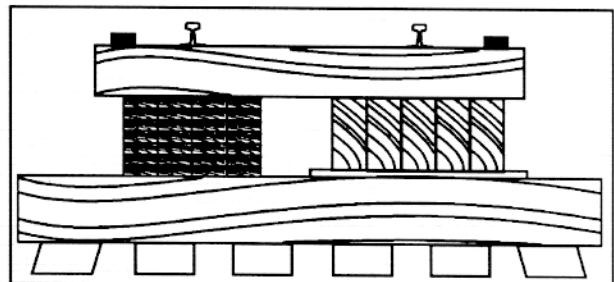


Exhibit 1. Cross Section of D'Hanis Bridge with Helper Stringer



located in an approximate 6-degree curve. The rail is 90 lb/yd jointed rail, while the guard rail is 85 lb/yd jointed rail. The bridge ties are 9 inches wide by 8.5 inches deep by 9 feet long and spaced 17 inches center to center. New ties were installed in 1989. Not more than 2 million gross tons of traffic has passed over the ties. A walkway is attached on either side of the bridge. The superstructure consists of two longitudinal packed chords containing five solid-sawn stringers (after strengthening), each measuring 6.5 inches wide by 15.5 inches deep. Half of the stringers measure 28 feet in length and are continuous over two spans. The substructure consists of 14-inch square caps supported by six pile bents both at the intermediate and abutment supports. Bent spacing is about 14 feet center to center. The structural components are composed of creosote-treated Douglas fir. The bridge was originally built in 1943.

TEST PROCEDURES

Avondale

The Avondale bridge was instrumented to obtain stringer vertical deflections. The west and east spans of the bridge were instrumented at the bent and midspan with displacement transducers referenced to the ground. The middle span was instrumented to obtain relative deflections and continuity between spans.

Testing was conducted with an AAR test train consisting of one four-axle EMD locomotive and three loaded hopper cars. Two of the cars were 263,000-pound cars, while the third one was a 286,000-pound car. Tests were conducted at 2, 5, 10, 15 and 20 mph in both directions. Prior to testing, the train was weighed and axle spacings were measured.

D'Hanis

As with the Avondale bridge, the D'Hanis bridge was also instrumented with displacement transducers to measure vertical deflections. However, in order to determine both dynamic wheel loads and train speeds, strain gages were installed on both rails at midspan. For the south chords of spans 2 and 8, displacement transducers were installed on all stringers at midspan and near each bent. Span 2 contained the re-centered helper stringer whereas span 8 did not have a helper stringer.

Testing was conducted with both revenue-service trains and a test train provided by Southern Pacific. A test train, consisting of one six-axle EMD locomotive

and three loaded hopper cars, was used to evaluate the dynamic response. Prior to testing, hopper-car geometry and weights were measured. Load tests with the test train were completed at crawl speed (about 2 mph) and at speeds of approximately 15, 30 and 40 mph.

RESULTS AND ANALYSIS

Chord Deflections: Avondale Bridge

Exhibit 2 displays relative deflections measured at the center of the bridge in 1995 prior to installing the helper stringer. The test train consisted of a four-axle EMD locomotive, AAR instrumentation car, and the TLV. Data was collected at a very limited sample rate, as these tests were primarily static. From this graph it is noticeable that the stringers did not behave as a unit. The highest deflection measured was about .2 inch on Stringer 5. Exhibit 3 displays relative deflections measured at the same location in 1997 after the installation of the helper stringer. The test train consisted of a four-axle EMD locomotive, two 263,000-pound loaded cars, and a 286,000-pound loaded car. As can be seen from the graph, the helper stringer shared the load with the other stringers, deflecting close to .25 inch. The five-ply chord behaved more as a unit in this test than in 1995, although the relative deflections were slightly higher (about 0.05 inch) due to the heavier test train. The maximum deflection measured in 1997 was .25 inch by Stringer 6.

Chord Deflections: D'Hanis Bridge

Exhibit 4 shows a comparison of relative stringer midspan deflections for the span 2 (helper stringer). Exhibit 5 shows the same information for span 8. The exhibits clearly illustrate several points:

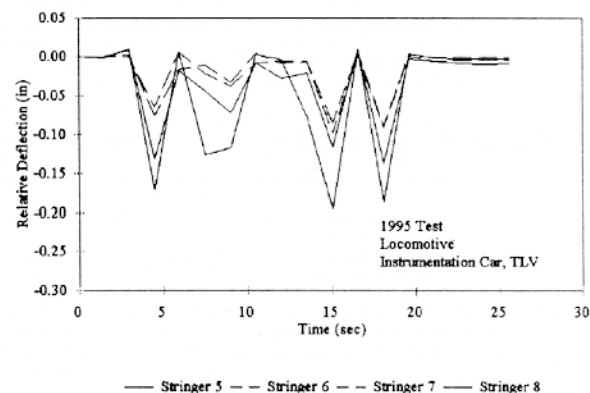


Exhibit 2. Relative Midspan Deflections at 10 mph on the West Chord, Avondale Bridge, 1995

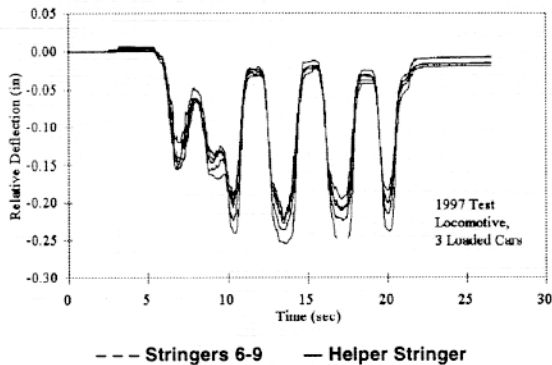


Exhibit 3. Relative Midspan Deflections at 10 mph on the West Chord, Avondale Bridge, 1997

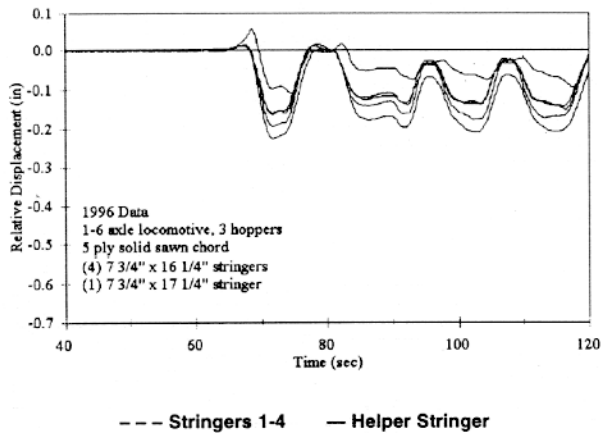


Exhibit 4. Relative Stringer Deflections at Midspan for Span 2, D'Hanis Bridge

- Overall, the helper stringer (span 2) reduced the magnitude of relative deflections for the chord.
- The helper stringer is contributing to the load distribution.
- Although the helper stringer is accepting a portion of the load, it really isn't helping the stringers in the chord deflect uniformly.

DISCUSSION

The intention of this study is to present results on the effectiveness of strengthening timber bridges using helper stringers. Two different installation techniques

were presented — with and without re-centering the chord. Each methodology has its pros and cons. Re-centering the chord takes up more time and construction. However, in theory, there is better load distribution. Additionally, if a bridge has short ties and/or short caps, this technique works best. On the other hand, not centering the chord takes up less construction time and effort, although bridge members such as ties and caps must be adequate in size and condition. Bridges with different design details, rail sizes, traffic characteristics, tonnage characteristics, and bridge deck fastening systems could have varying results from these strengthening methods.

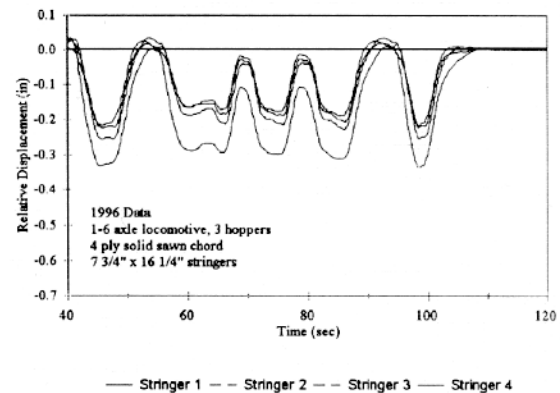


Exhibit 5. Relative Stringer Deflections at Midspan for Span 8, D'Hanis Bridge

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