RINARD BRIDGE
Spanning Little Muskingum River at County Road CR-406
Wingett Run vicinity
Washington County
Ohio

HAER OH-130

HAER OH-130

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
U.S. Department of the Interior
1849 C Street NW
Washington, DC 20240-0001

HISTORIC AMERICAN ENGINEERING RECORD

RINARD BRIDGE

HAER No. OH-130

Location: Spanning Little Muskingum River at County Road CR-406, Wingett Run vicinity, Washington County, Ohio

Rinard Bridge is located at latitude: 39.536883, longitude: -81.222132. The coordinate represents the east end of the bridge. It was obtained on September 27, 2012, using Google Earth imagery dated April 20, 2011. The Rinard Bridge location has no restriction on its release to the public.

Structural Type: Smith truss (Type 3) wooden covered bridge

Dates of Construction: Original 1876; rebuilt 1913, 1938, 2006

Previous Use: Vehicular bridge

Present Owner: Washington County, Ohio

Present Use: Historic landmark and tourist attraction

Significance: Rinard Bridge is significant as one of ten surviving Type 3 Smith trusses. It was used as the basis for a comparative structural study of Type 2 and Type 3 Smith trusses (see "Structural Study of Smith Trusses," HAER No. PA-645).

Authors: Stephen Buonopane, Sarah Ebright, Alex Smith, Bucknell University, 2012

Project Information: The National Covered Bridges Recording Project was undertaken by the Historic American Engineering Record (HAER), a long-range program to document historically significant engineering and industrial works in the United States. HAER is administered by the Heritage Documentation Programs Division (Richard O'Connor, Chief), a division of the National Park Service, U.S. Department of the Interior. The Federal Highway Administration's National Historic Covered Bridge Preservation Program funded the project. Additional financial support was provided by the Rooke Chair in the Social and Historical Context of Engineering at Bucknell University.

Christopher H. Marston, HAER Architect, served as project leader. Prof. Stephen H. Buonopane led the field work, with engineering students Sarah Ebright and Alex Smith, all of Bucknell University. David Simmons of the Ohio Historical Society, Ron Mattox of Jobes Henderson & Associates, Dario Gasparini of Case Western Reserve University, and Emily Daniels of Bucknell University provided assistance.

Related Documentation: Structural Study of Smith Trusses, HAER No. PA-645
Kidd's Mill Bridge, HAER No. PA-622
Powder Works Bridge, HAER No. CA-313

Chronology[1]

1805	America's first covered bridge built at Philadelphia.
ca.1835	Robert W. Smith born in Miami County, Ohio.
1867	Robert W. Smith received U.S. Patent No. 66,900.
1869	Robert W. Smith received U.S. Patent No. 97,714 and established Smith Bridge Co. in Toledo, Ohio.
1871	First bridge (Henderschott Ford Bridge) crossing at this location constructed.
1875	Henderschott Ford Bridge washed out.
1876	Smith Bridge Co. builds Rinard Bridge at this location.
1891	Smith Bridge Co. sold.
1898	Robert W. Smith died.
1913	Rinard Bridge washed from piers and rebuilt using salvaged timbers.
1938	Rinard Bridge washed from piers and rebuilt using salvaged timbers.
1976	Rinard Bridge listed in the National Register of Historic Places.
1991	Rinard Bridge closed to vehicular traffic.
2004	Rinard Bridge washed from piers on September 18. Bridge comes to rest downstream largely intact.
2004	Remains of Rinard Bridge lying in streambed further damaged by second flood.
2006	Rinard Bridge reconstructed using salvaged timbers.
2010	Engineering, design and construction of Rinard Bridge studied as part of comparative "Structural Study of Smith Trusses" with Kidd's Mill Bridge.

[1] Based on Miriam F. Wood and David Simmons, *Covered Bridges: Ohio, Kentucky, West Virginia* (Wooster, Ohio: The Wooster Book Co., 2007); "Rinard Covered Bridge III," interpretive sign at bridge site, 2006; and Historic American Engineering Record (HAER), National Park Service, U.S. Department of the Interior, "Kidd's Mill Bridge," HAER No. PA-622, and "Powder Works Bridge," HAER No. CA-313.

Introduction

The general history of wooden covered bridges has been previously researched and published in multiple sources, several of which are listed in the references. Wooden covered bridges were built in the United States throughout the nineteenth century using a variety of bridge truss forms. The four most common truss types are generally accepted to be the Burr arch, Town lattice, Long truss and Howe truss. By the late nineteenth century, wooden bridge trusses began to incorporate iron structural components, which ultimately led to the transition to all metal bridge trusses.

In the late 1860s, Robert W. Smith patented a wooden bridge truss and formed the Smith Bridge Company. His company would become a highly successful regional bridge design, fabrication and construction company, based on Smith's patented truss as well as more common truss forms. The Smith truss was a frequently used timber bridge form in Ohio and Indiana. Brief histories of the Smith Bridge Co. and specific wooden covered bridges built with Smith trusses appear in surveys of covered bridges in mid-western states.[2]

Smith trusses relied on timber for all of their main structural members at a time when many truss bridges were transitioning to a combination of iron and wood. The Smith trusses use notched and shouldered joints between the main tension diagonals and chords in order to effectively transfer tension forces. Because the timbers were prefabricated in a factory-setting, the relatively complex joinery could be accurately fabricated. The importance of factory-style fabrication to the success of Smith trusses has been established based on a study of the design and construction of the Cataract Falls Bridge in Owen County, Indiana (see HAER No. IN-104).[3]

The basic form of Smith trusses is two overlapping sets of diagonals members and no vertical members. Smith trusses are classified as Type 1, 2, 3 or 4 based on the arrangement of the diagonal braces, according to the scheme established by Raymond C. Wilson in 1967.[4] Figure 1 shows the truss elevations for the Smith truss Types 1, 2, 3 and 4. No Type 1 trusses are known to have been constructed.

The Rinard Bridge (Type 3) and the Kidd's Mill Bridge (Type 2) were used as the basis for a detailed, comparative engineering study into the structural design and behavior of Smith trusses.[5] The structural analyses demonstrated that the Smith trusses do reflect an understanding of fundamental structural behavior and design consistent with nineteenth-century practice, although the specific design methods used by Smith remain unknown. In both the Kidd's Mill Bridge (see HAER No. PA-622) and Rinard Bridge,

---

[2] Wood and Simmons; Richard Sanders Allen, *Covered Bridges of the Middle West* (New York: Bonanza Books, 1970).

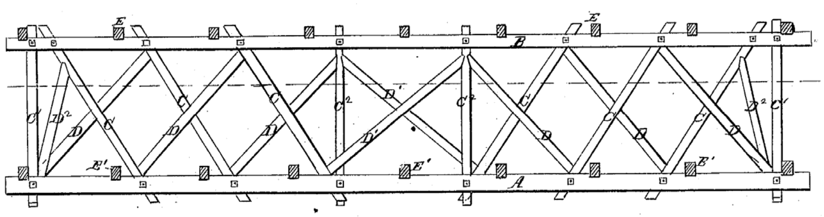
[3] Matthew Reckard, "Smith Trusses: Bringing Covered Bridges into the Industrial Age," presented at First National Covered Bridges Conference, University of Vermont, Burlington, 2003.

[4] Raymond E. Wilson, "The Story of the Smith Truss," *Covered Bridge Topics* 25 (April 1967): 3-5.

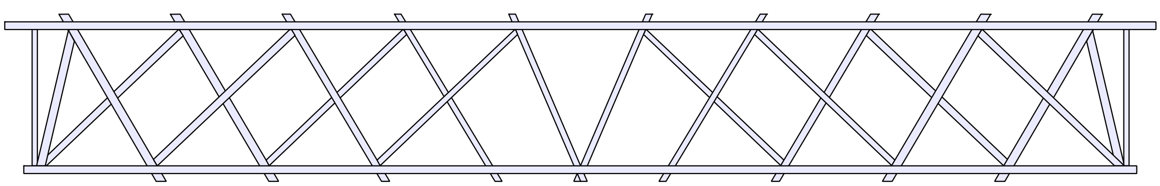
[5] Historic American Engineering Record (HAER), National Park Service, U.S. Department of the Interior, "Structural Study of Smith Trusses," HAER No. PA-645.

the cross-sectional sizes of the diagonal members are reduced moving from the ends of the span towards the centerline, as the diagonals at the ends will carry larger forces than at the center. Axial and bending stresses due to both self-weight and live loads were calculated using linear structural analysis. Maximum combined stresses were approximately equal to typical allowable stresses of 750 psi to 800 psi, still leaving sufficient factor of safety against member failure.

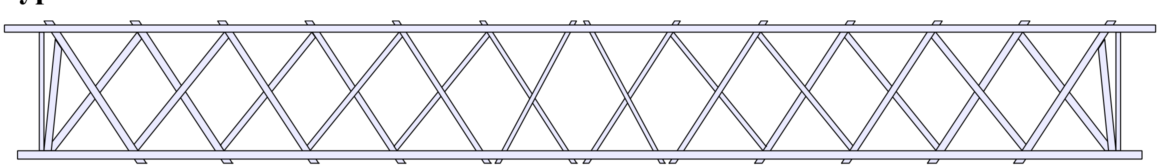
The ability of the Smith trusses to carry large concentrated live loads was found to be limited by the unloading of bearing-style connections at the ends of the compression members. The maximum concentrated live load that could be supported was estimated to be 5.3 tons. Analysis of the typical notched and shouldered connections between tension diagonals and chords demonstrated that the shoulders are subject to shear failure, especially in combination with the presence of out-of-plane forces.



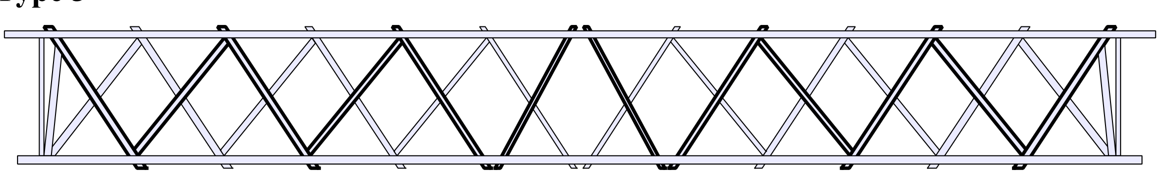
(a) Type 1 (from U.S. Patent No. 66,900)



(b) Type 2



(c) Type 3



(d) Type 4 (Members outlined in bold represent two parallel members.)

Figure 1. Smith Truss Types 1, 2, 3 and 4.

Description

Rinard Bridge is a Type 3 Smith truss, with an overall span of 130'-8" measured from the centerlines of the vertical end-posts (L1-U1 and L11-U12). Figure 2 and Figure 3 show exterior and interior views of the bridge, respectively. Figure 4 shows an elevation of one of the trusses of Rinard Bridge with dimensions of the truss panels. The panel lengths are measured from the intersection of the centerline of the diagonal tension member with the top surface of the lower chord or bottom surface of the upper chord. The upper chords extend approximately 4'-7" beyond the centerlines of the endposts, while the lower chords extend approximately 2'-11". The width of the bridge is approximately 17'-4" measured between the inside faces of the upper chords. The width of the roadway surface is also approximately 17'-4". The transverse floor beams are 2" x 13" in cross-section and spaced at approximately 18". The decking consists of two layers of 2" x 10" planks laid flat and diagonally. The dimensions are based on field measurements obtained during a site visit in July 2010 and adjusted slightly for symmetry and equal spacing of panel points and on the construction drawings from the 2006 reconstruction.[6]

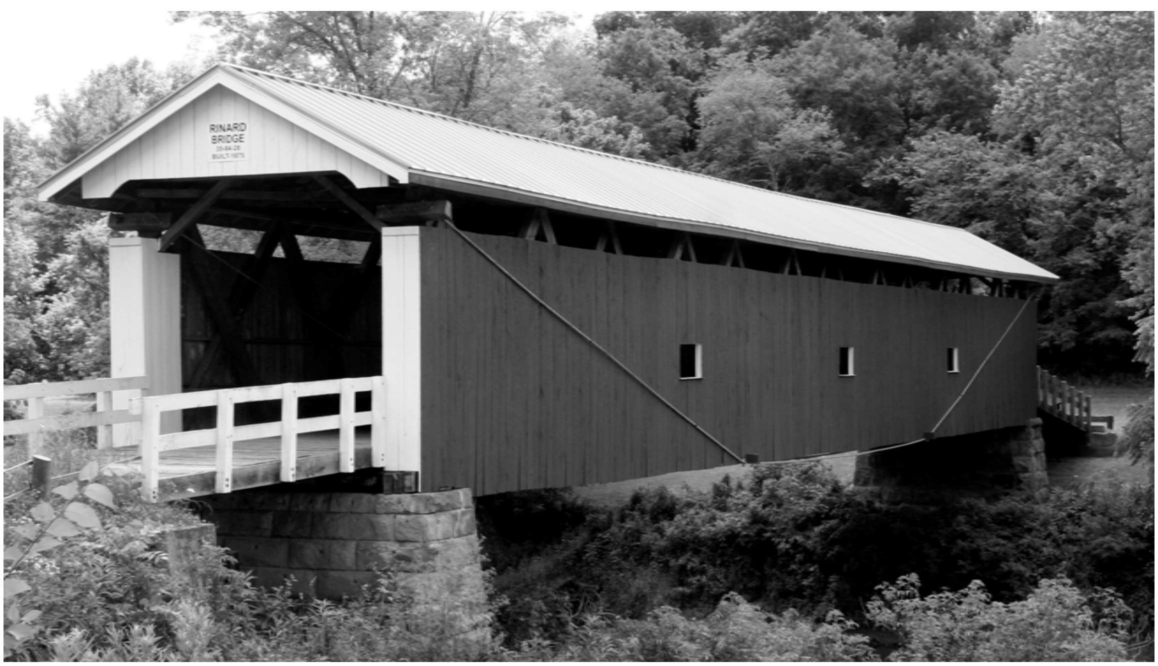


Figure 2. Rinard Bridge, exterior view looking north (upstream). Photograph by Stephen Buonopane, July 1, 2010.

[6] Gresham, Smith and Partners, "Rinard Covered Bridge," Ludlow Township, Washington County, State of Ohio, Dept. of Transportation, 2005, sheets 1 through 19.

Figure 3. Rinard Bridge, interior view. Photograph by Stephen Buonopane, July 1, 2010.

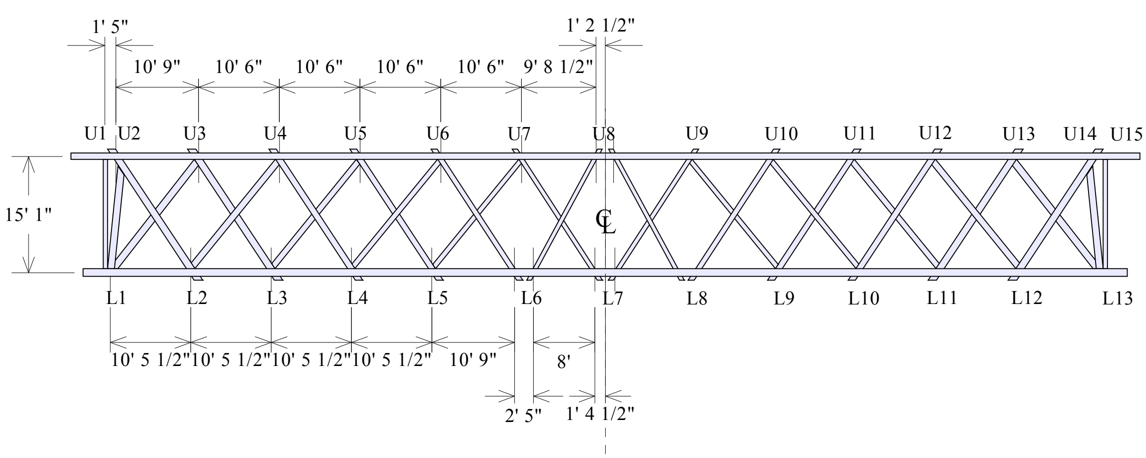


Figure 4. Rinard Bridge Truss with Dimensions.

Table 1 summarizes the dimensions of the main structural members of the Rinard Bridge. The upper chord is composed of three parallel timbers measuring 3" x 5.5" in cross-section. The lower chord is composed of three parallel timbers 3" x 6" in cross-section. Each chord timber is approximately 32'-4" long with the joints staggered approximately every 10'-8". Chord splices occur near the middle of every panel and are staggered such that only one chord timber is spliced in any given panel. Timbers in the lower chord also include a fishplate connection across the splice, as the lower chord is in tension. The individual timbers of both chords are separated by approximately 1.5" using spacer blocks of approximately 3" wide x 9-1/4" long. The spacer blocks are recessed into approximately 3/4" deep notches cut into the faces of the chord timbers. The chord timbers are clamped together with through bolts of 5/8" diameter. The bolts are placed at the joints, within panels and near the ends of spliced chord members. The bolts at joints are not intended to contribute to the strength of the joint as they are not positioned through the center of the joint.

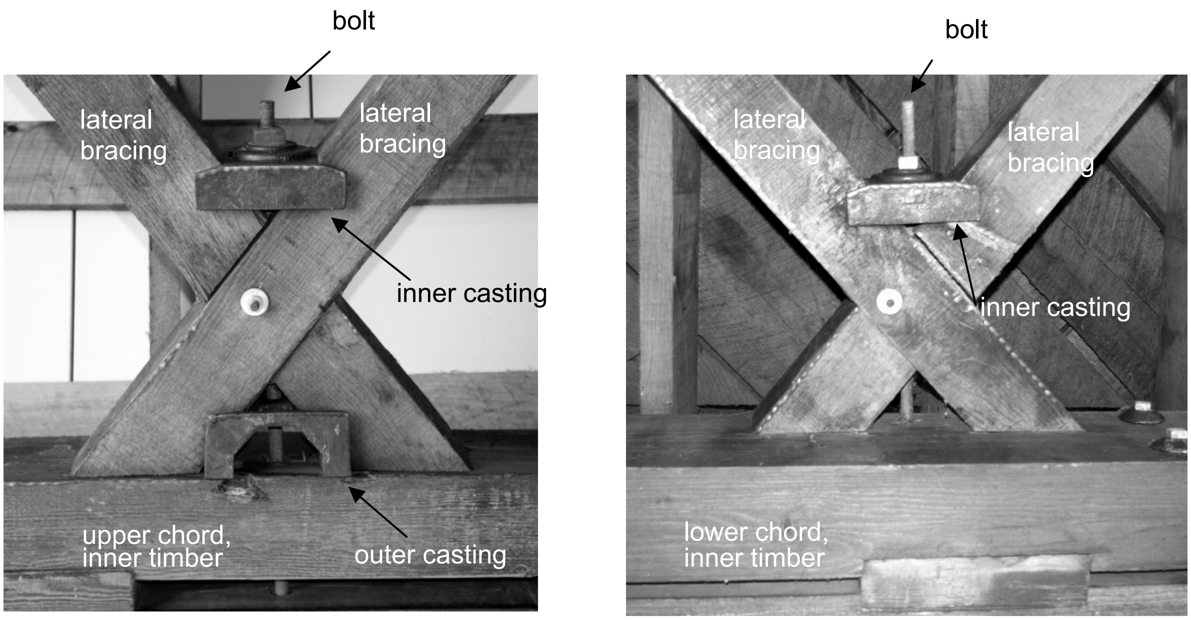
The tension diagonals of Rinard Bridge are inclined at approximately 60 degrees, and the compression diagonals are inclined at approximately 45 degrees. The diagonal members vary in cross-sectional size in relation to the axial forces carried under uniform loads. The diagonals at the ends of the bridge carry the largest tension and are 7" x 11" in cross-section. The diagonals near the mid-span of the bridge carry the least axial force and are 7" x 6" in cross-section. The tension diagonals (counter-braces) are connected to the chords with notched and shouldered connections and therefore can effectively transfer their force to the chords. The compression diagonals (braces) bear against the sides of the tension diagonals, and their connections are capable of transferring only compression forces. The use of the notched and shouldered connections for the tension diagonals is a critical design element of the Smith truss and is discussed in detail in the "Structural Study of Smith Trusses" (see HAER No. PA-645). A detailed drawing of a similar type of connection from Kidd's Mill Bridge appears as Figure 41 in HAER No. PA-645.

Lateral bracing exists in the planes of both the upper and lower chords. The lower lateral bracing consists of 5" x 5" timbers arranged in an X-bracing pattern. The braces cross one another at the bridge center-line and also adjacent to each chord, approximately 6" to 8" from the inner face of the lower chord. Figure 5 shows the connections of the lateral bracing to the upper and lower chord. Half-lap joints are used at all crossing points so that the crossing timbers all lie within the same plane. The braces are attached to the lower chord with a casting and bolt that passes through the intersection of the chords and all three timbers of the lower chord (see Figure 5). The design and construction details of this connection are consistent with Smith's 1869 patent (U.S. Patent No. 97,714), in which the lateral bracing system and its connections are among the specific patent claims. At the time of the construction of the Rinard Bridge, the typical lateral bracing system would have been to use iron tension rods across the full width of the bridge. Smith's connection detail allows the use of timber diagonal bracing with a fairly simple but effective connection detail.

Table 1. Dimensions of Structural Members.

Element*	Type	Out-of-Plane Dimension (in)	In-Plane Dimension (in)
U1U2, U2U3, U3U4, U4U5, U5U6, U6U7, U7U8	upper chord	3x5.5" = 16.5	10
L1L2, L2L3, L3L4, L4L5, L5L6, L6L7	lower chord	3x6" = 18	12
L1U2	end compression diagonal	7	11
L1U3	compression diagonal	7	11
L2U4, L3U5	compression diagonal	7	10
L4U6	compression diagonal	7	8
L5U7	compression diagonal	7	7
L6U8	compression diagonal	7	6
L2U2, L3U3	tension diagonal	7	11
L4U4	tension diagonal	7	10
L5U5	tension diagonal	7	9
L6U6	tension diagonal	7	8
L7U7	tension diagonal	7	7
L1U1	end post	2x7" = 14	7

*Element names are listed for the left-half of the truss only. Corresponding members in the right-half of the truss have identical dimensions and properties.



(a) Upper chord **(b) Lower chord**

Figure 5. Lateral bracing connections to chord at Rinard Bridge (views from below). Photograph by Stephen Buonopane, July 1, 2010.

The upper lateral bracing is also constructed from 5" x 5" timbers in the same overall geometric pattern as the lower bracing. The attachment of the upper bracing to the chord includes a second iron casting, placed adjacent to the inner face of the upper chord (see Figure 5). This second casting does not appear in the 1869 patent. These castings have prongs allowing them to be hammered into the face of the chord timber. With the casting in place, the projecting flanges could temporarily support the lateral bracing while the inner casting and through-bolt were installed. At Kidd's Mill Bridge, the lower lateral bracing system has similar castings and connections to those found at Rinard, while the upper lateral bracing is connected in a different manner.[7] Similar connections and castings exist at the Powder Works Bridge (see HAER No. CA-313).[8]

Rinard Bridge also uses an iron casting to support the end compression diagonal (L1-U3 or L13-U13) at the lower chord, as shown in Figure 6. No similar castings were found at Kidd's Mill Bridge, although the end joints at the lower chord do show evidence of past repairs. Similar castings exist at the Powder Works Bridge.[9] The use of such castings in other Smith trusses remains undocumented.

---

[7] "Structural Study of Smith Trusses," HAER No. PA-645, 2012.

[8] Christopher Marston, personal communication with authors, September 20, 2011.

[9] Christopher Marston, personal communication with authors, September 20, 2011.

Figure 6. Rinard Bridge casting at joint L1 and L13. Photograph by Ron Mattox.

The roof is supported by 2" x 6" rafters spaced at 2'-6" and supported on the upper chord. The rafters are also supported by a longitudinal ridge 1" x 8" beam and transverse 2" x 6" rafter ties. The present roof is a standing-seam metal roof supported on wood strapping. The original roofing material is presumed to have been wooden shingles, although details are not known. The siding consists of 1" x 10" boards oriented vertically attached to 2" x 4" horizontal nailers. Based on photographic evidence, some of the previous versions of the bridge have included battens on the siding while other versions have not. The siding ends about 2' below the upper chord providing a continuous horizontal opening above the siding.

The end portals contain diagonal sway bracing consisting of two 6" x 6" timbers extending from the horizontal rafter tie to the vertical end-posts, approximately 3' below the lower chord, and also attached to a horizontal portal brace at the level of the upper chord. This style of portal bracing is described in Smith’s 1869 patent (U.S. Patent No. 97,714) and specifically cited as one of his patent claims. The patent drawing does not include the intermediate rafter tie, and therefore the braces extend to the ridge line.

The bridge presently has a supplementary tension rod system (see Figure 2 and Figure 3), which is not original to the bridge. A photograph dated 1933 shows the bridge without the tension rods. When the bridge was reconstructed in 2004, the tension rod system was restored to its prior configuration. Each tension rod is composed of three straight segments of 1-$^{1}/_{2}$" metal rod joined by circular hooked ends. The first segment extends from the upper end of the vertical end-posts to a bearing block adjacent to joint L5. The second segment extends horizontally between bearing blocks adjacent to

Figure 7. View of Rinard Bridge dated 1933. Photograph courtesy of Washington County Historical Society, Marietta, Ohio.

joints L5 and L9. The final segment extends from L9 to the other vertical end post. There are four sets of tension rods in all, two per truss. One tension rod system runs along the inside of the truss and is visible from inside the bridge. The second tension rod system runs outside of the siding.

The existing piers are constructed of dry-laid stone and appear to be original. The position of the piers, elevation of the bridge floor and elevation of surrounding land require short, inclined approach spans at both ends of the bridge. The current bridge has an approach span of approximately 32' length at the west end and 21' at the east end. The current approach spans are supported on steel stringers. Historical photographs of the bridge site show that the bridge had similar approach spans likely constructed entirely out of timber.

History

The first bridge crossing at this site was the Henderschott Ford Bridge, constructed in 1871 and washed out by a flood in August 1875. The first Rinard Bridge was constructed in 1876 by the Smith Bridge Co. at a total cost of $2,520.[10] In both 1913 and 1938, the Rinard Bridge was washed off its piers but reconstructed from the timbers salvaged from the river. In 1991, the current CR-4006, located just north (upstream), bypassed the Rinard Bridge. In September 2004, the Rinard Bridge was washed off its piers for the

[10] Wood and Simmons.

third time but remained largely intact in the river downstream. Several weeks later, a second flood further damaged the remains of the bridge. The remains were once again salvaged from the river, and the Righter Company of Columbus, Ohio, using an engineering design by Gresham, Smith and Partners of Columbus, Ohio, reconstructed the bridge in 2006.[11] The bridge was listed in the National Register of Historic Places in 1976.[12] The bridge currently serves the local community as part of a recreational area and as a tourist attraction and is significant as an example of a Smith truss (Type 3).

[11] "Rinard Covered Bridge III," 2006.

[12] "Rinard Covered Bridge," National Register of Historic Places, listed October 8, 1976.

References

Allen, Richard Sanders. *Covered Bridges of the Middle West*. New York: Bonanza Books, 1970.

Fletcher, Robert and J.P. Snow. "A History of the Development of Wooden Bridges." *Transactions of the American Society of Civil Engineers* 99 (1934): 314-408.

Gresham, Smith and Partners. "Rinard Covered Bridge." Ludlow Township, Washington County, State of Ohio, Dept. of Transportation, 2005. Sheets 1 through 19.

Historic American Engineering Record (HAER), National Park Service, U.S. Department of the Interior. "Cataract Falls Bridge." HAER No. IN-104.

———. "Kidd's Mill Bridge." HAER No. PA-622.

———. "Powder Works Bridge." HAER No. CA-313.

———. "Structural Study of Smith Trusses." HAER No. PA-645.

James, J.G. "The Evolution of Wooden Bridge Trusses to 1850: Part 1." *Journal of the Institute of Wood Science* 9 (1982): 116-35.

———. "The Evolution of Wooden Bridge Trusses to 1850: Part 2." *Journal of the Institute of Wood Science* 9 (1982): 168-93.

Marston, Christopher. Personal communication with authors, September 20, 2011.

Mattox, Ron. Personal communication with authors, May 17, 2010.

McKee, Brian J. "Smith, Partridge, and Brown Trusses as They Were Really Built." *Covered Bridge Topics* 58 (Summer 2000): 13-15.

Reckard, Matthew. "Smith Trusses: Bringing Covered Bridges into the Industrial Age." Presented at First National Covered Bridges Conference, University of Vermont, Burlington, 2003.

"Rinard Covered Bridge." National Register of Historic Places, listed October 8, 1976.

"Rinard Covered Bridge III." Interpretive sign at bridge site, 2006.

Wilson, Raymond E. "The Story of the Smith Truss." *Covered Bridge Topics* 25 (April 1967): 3-5.

Wood, Miriam F. and David Simmons. *Covered Bridges: Ohio, Kentucky, West Virginia*. Wooster, Ohio: The Wooster Book Co., 2007.

ADDENDUM TO:
RINARD BRIDGE
Spanning Little Muskingum River at County Road CR-406
Wingett Run vicinity
Washington County
Ohio

HAER OH-130
HAER OH-130

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
U.S. Department of the Interior
1849 C Street NW
Washington, DC 20240-0001

ADDENDUM TO:

HISTORIC AMERICAN ENGINEERING RECORD

RINARD BRIDGE

HAER No. OH-130

The following pages are an addendum to a 14-page report that was previously transmitted to the Library of Congress in 2012.

ILLUSTRATED APPENDIX

This illustrated appendix is an addendum to the HAER report previously transmitted to the Library of Congress in 2012. Historic images (fig. 8-10) are courtesy the John Diehl Collection, Ohio History Connection; all date from September 4, 1949. All color digital photographs (fig. 11-2x) were taken by Martin Stupich, April 2015.

Figure 8. View of Rinard Bridge, looking northeast, showing supplementary tension rods, 1949. Courtesy John Diehl Collection.

Figure 9. Approaching bridge from the east, view southwest, 1949. Courtesy John Diehl Collection.

Figure 10. Interior view of bridge, showing Smith truss type 3. Courtesy John Diehl Collection.

Figure 11. Oblique view of Rinard Bridge, looking southwest

Figure 12. Detail of west dry-laid stone pier, showing tie-down rods beneath deck, view to west

Figure 13. General view of south elevation of bridge over Little Muskingum River, view to north

Figure 14. Detail of east pier and supplementary tension rods, view to east.

Figure 15. Lower lateral bracing in Smith's X-bracing pattern. Note bolt and casting connections at edge of lower chords. View to east.

Figure 16. Interior detail of west end of north truss, showing end compression diagonal (80 degrees), tension diagonals (60 degrees), and compression diagonals (45 degrees), view to north

Figure 17. Detail of notched connection of end compression diagonal and tension diagonal below upper chord.

Figure 18. Interior of Smith truss, view to east


Figure 19. Interior detail of roof structure at west end, view to west