7 Extant Lenticular Iron Truss Bridges from the Berlin Iron Bridge Company

Alan J. Lutenegger

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ABSTRACT

Of the estimated five to six hundred lenticular iron truss bridges built by the Berlin Iron Bridge Company over a twenty year period from about 1880 to 1900 only about 50 bridges remain. Extant bridges are located in Hew Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania and Texas. Over the past 5 years, the author has visited all but two of the extant bridges and documented their geometry and condition. Some of the bridges are still in service, some are closed to traffic, some have been adapted for use as pedestrian bridges and some are in storage awaiting a final decision on their fate. These bridges are an example of a special type of catalog bridge available in the mid to late 19th Century. The bridges represent a unique design during a time when many bridge companies were competing for contracts in a highly competitive market. These bridges were

the only ones to use the lenticular design by a prominent bridge builder of the era. A background on the lenticular design is given and a statistical summary of the geometry of the remaining bridges is given. The data collected provide insight into the design and applicability of the bridges that were selected at specific locations.

INTRODUCTION

The author visited all but four of the known remaining lenticular iron truss bridges built by the Berlin Iron Bridge Company (BIBCO) to gather information on the specific geometry and construction of the various bridge components as an initial phase in evaluating the engineering approach used for these bridges. The bridges range in age from 1878 to 1896 and therefore essentially represent the full time period over which the bridges were built. Pony truss bridges and through truss bridges including suspended decks, mid deck and under deck designs are represented in the remaining bridges. A total of 57 locations were visited and a total of 69 structures were examined since there are some locations with more than one structure. All but seven of the known structures have been examined at this time. The author also visited the BIBCO lenticular bridges in Texas, which may have been the only lenticular bridges built west of the Mississippi River. Even though the number of extant bridges represents only about 15% of the estimated total number of bridges produced, there appears to be a sufficiently good representation of nearly every style of bridge produced by the company.

Darnell (1979) presented a partial listing of surviving lenticular truss bridges and at that time included 48 locations (total of 57 individual spans). The list did not include any bridges in New Hampshire, Rhode Island, Pennsylvania or the bridges in Texas. Unfortunately, a number of the bridges in Darnell's 1979 list have been removed and demolished but a number of other bridges have been rediscovered and are included in the list in this paper. A description of the extant lenticular bridges in Massachusetts has recently been given by Lutenegger and Cerato (2005). At this writing bridges are known to exist in eight states, primarily in New England as well as Texas. Recent renewed interest in these bridges has produced a new review of their structural analysis (Boothby 2004). In this paper, an examination is made of the configuration of the remaining bridges including an evaluation of the overall shape as well as a look at some individual components. No attempt has been made to perform a detailed structural analysis. Rather, an initial analysis of the dimensions of the bridges has been performed to allow some insight into the process used by the designers to select specific geometries and components at various locations.

LENTICULAR TRUSS BRIDGES

During the latter part of the 19th Century and the beginning of the 20th Century, the Berlin Iron Bridge Co. of East Berlin, Connecticut, manufactured and erected almost 400 lenticular truss bridges in the United States (Darnell 1979). These bridges are sometimes referred to as "pumpkin-seed bridges", "fish-belly bridges", "cats-eyes bridges", "elliptical truss bridges", "double bowstring", or "parabolic truss bridges" because of their unique lens shape. Like many other iron truss bridges of the day,

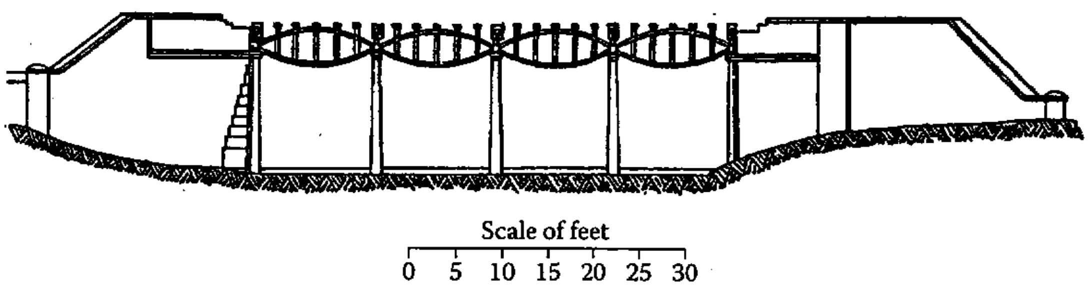

FIGURE 7.1 Stockton & Darlington Railway Bridge 1823.

these bridges were, in effect, "mass produced" as the components were built in a factory, sent to the site, and then assembled. Many of the components were used repeatedly for different spans or applications.

According to James (1981) lenticular shaped bridges had previously been used in Europe as early as 1822. Wooden bridges with a lenticular shape had been used in Germany by Laves. It appears that one of the first uses of this type of design in iron was George Stephenson's railway bridge designed in 1822 and built between 1823 and 1824 to carry the Stockton & Darlington Railway over the river Gaunless in West Auckland, UK. As shown in Figure 7.1, the bridge consisted of four spans of 12 ½ ft. (originally three spans with a fourth span added in 1825) with top and bottom chords of wrought iron and the vertical members of cast iron. The members were built by Burrell & Company of Newcastle. The bridge was opened on September 27th, 1825 and was in use until about 1856. The bridge stood intact but unused until 1901, when it was dismantled and moved to storage. In 1928 the bridge was re-erected at the York Railway Museum and is currently on display at the UK National Railway Museum. The author has recently been allowed to examine and document this bridge which is still in remarkably good shape.

One of the most notable bridges of this style was I.K. Brunel's 1855 twin span lenticular Royal Albert Railway Bridge across the Tamar in Saltash UK. This bridge used tubular upper chords with each span having a span of 445 ft. (center to center of the piers). In 1860, the Mainz Bridge was built over the Rhine River in Germany and consisted of at least two large spans and two shorter spans. This bridge shows remarkable similarities in form to the lenticular truss bridges built twenty-five years later by the Berlin Iron Bridge Company and discussed later in this paper.

In the U.S., the great bridge engineer Gustav Lindenthal built a lenticular shaped twin span bridge across the Monongahela River at Smithfield Street in Pittsburgh, PA, in 1883. Lindenthal (1883) referred to this shape as a "Pauli Truss" after the famous German bridge engineer Friedrich August von Pauli (1802–1883). Each span of the bridge originally was constructed using two trusses; a third truss was added to carry streetcar traffic in 1891. This bridge replaced an earlier one designed and built by John Roebling, but did not really receive the attention that perhaps Lindenthal had been hoping for. This may have been in part related to the fact that another bridge which opened in 1883, the Brooklyn Bridge, may have had considerably more importance at the time. However, the structures of Brunel and Lindenthal were unique, single event, monumental bridges, never to be duplicated in any close form by any other engineer at any other location.

By contrast to these few single large scale structures, the hundreds of lenticular truss bridges built by the Berlin Iron Bridge Company were catalog bridges and their design was duplicated many times throughout the New England and Mid-Atlantic regions. In fact, BIBCO built the only lenticular iron/steel truss bridges known to have been erected in the U.S. aside from Lindenthal's Smithfield Street Bridge. These bridges were only used for vehicular traffic and were generally considered too light to be used for railroad and trolley loads, although it is known that at least one, in Portland, Maine, did also serve as a trolley bridge. Considering that the most common traffic of the era (1880–1900) consisted of horse-drawn carts or wagons, it is amazing that any of the bridges survived through the automobile age to the present day. Most of the bridges that were lost over the years were not because of failures from overloading; most were swept away during severe floods.

Darnell (1979) described a number of lenticular bridges and gives a detailed account of the history of the Berlin Iron Bridge Co. In addition to the uniquely shaped lenticular truss bridges, BIBCO also built conventional steel truss bridges and even built a few pedestrian suspension bridges, the most notable of which were erected in Keesville, N.Y. and Milford, N.H. In addition to bridges, BIBCO had a thriving business, building roof trusses, water towers, and complete steel frames for buildings. The company was very persistent in its advertising and routinely placed ads in a number of important and influential trade magazines and journals of the day, including the Transactions of the ASCE.

THE PATENTS OF WILLIAM O. DOUGLAS

A patent, No. 202,526, was issued by the U.S. Patent Office on April 16, 1878 to William O. Douglas, of Binghamton, N.Y., for a truss bridge, described in the patent as "A combination of two or more elliptical trusses connected as herein described with the floor and joints and necessary flooring to form a through deck or swing bridge". Douglas's patent drawings of 1878 included only three basic configurations of bridges, namely, suspended deck, under deck and mid deck bridges, as shown in Figure 7.2. Two of Douglas's patent drawings showing a suspended deck design (i.e., deck tangent to the lower chord) are shown in Figure 7.2.

Earlier patents for bridges with similar features to those of Douglas's (especially the parabolic or elliptical shape) had previously been issued by the U.S. Patent Office; on March 27, 1849 to James Barnes (No, 6,230); on September 2, 1851, to Edwin Stanley, N.Y. (No. 8,337); on August 21, 1855 to Horace L. Hervey and Robert E. Osborn (No. 13,461); on March 28, 1871 to Ferdinand Dieckman (No. 113,030); on October 22, 1872 to G.E. Harding (No. 132,398); and on June 11, 1873 to James B. Eads (No. 142, 381). Even after Douglas received his patent and the Berlin Iron Bridge Company had been in full production for many years, the U.S. Patent Office continued to grant patents for bridge designs with noted similarities to previous structures, for example on December 9, 1884 to Charles Strobel (No. 309,171); and on August 18, 1896 to John Semmes (No. 566,233).

Douglas had published his suggestion for his bridge design in an 1877 printing of the *Scientific American Supplement*, showing an illustration of his proposed design, Figure 7.3. Douglas (1877) referred to his design as "An Elliptical Truss Bridge"

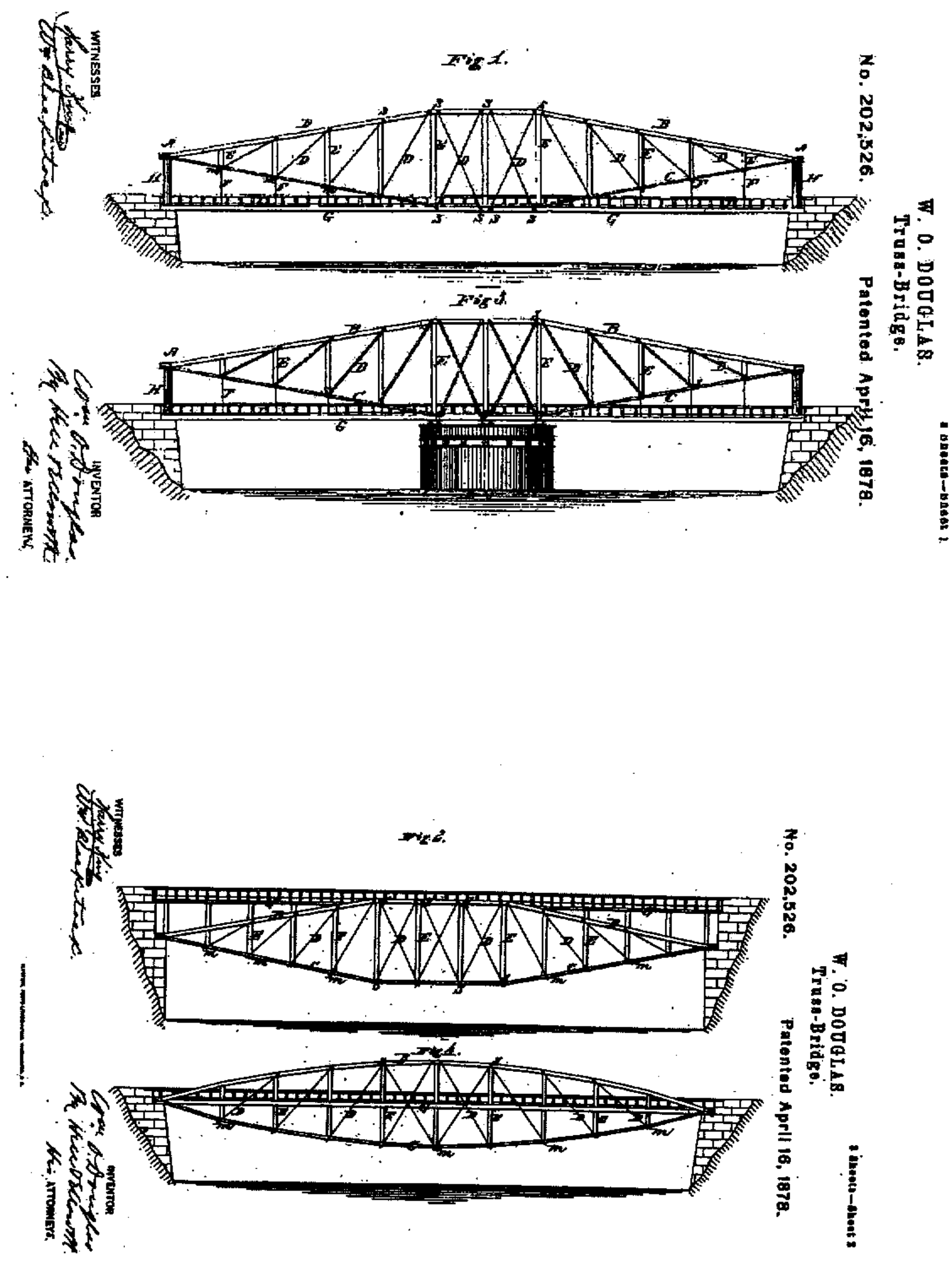

FIGURE 7.2 Drawings from William O. Douglas's 1878 patent.

noting that "In a bridge as above illustrated in Figure 7.2, we have the arch and suspension principles united, forming an elliptical truss. The thrust of the arch equipoises and is equipoised by the pull of the cable". He further noted that "The roadway is suspended to the two chords so that the arch carries one half of the load and the cable the other, under which circumstances the thrust and the pull at the top of end posts will be equal. The end posts have only to support the dead load of the bridge". Douglas's public disclosure of his proposed design (July 14, 1877) predates

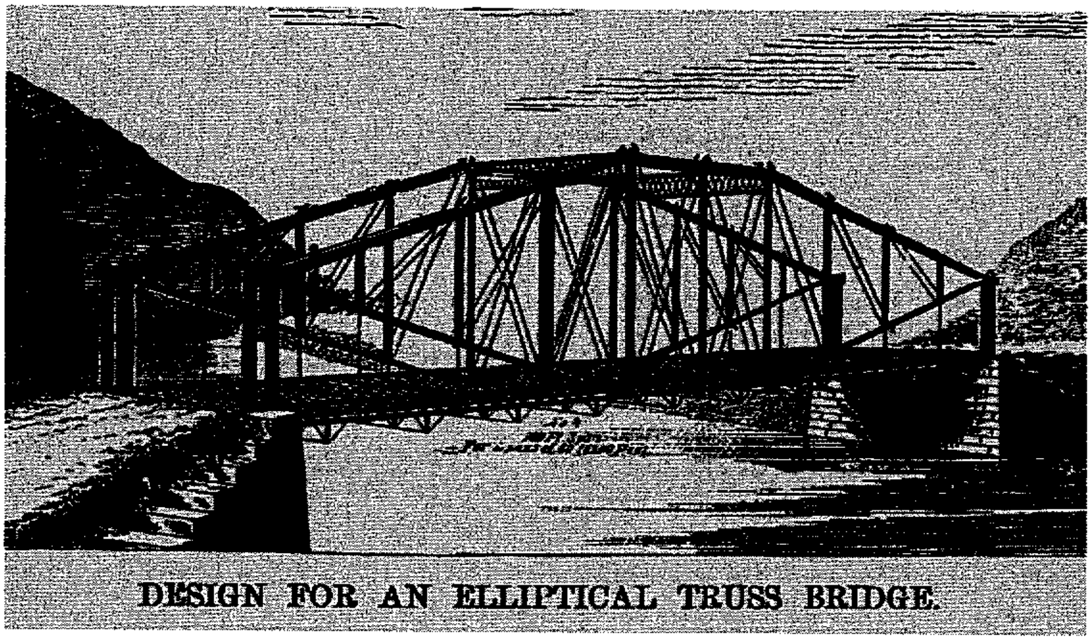

FIGURE 7.3 Design for elliptical truss bridge.
Source: Douglas (1877).

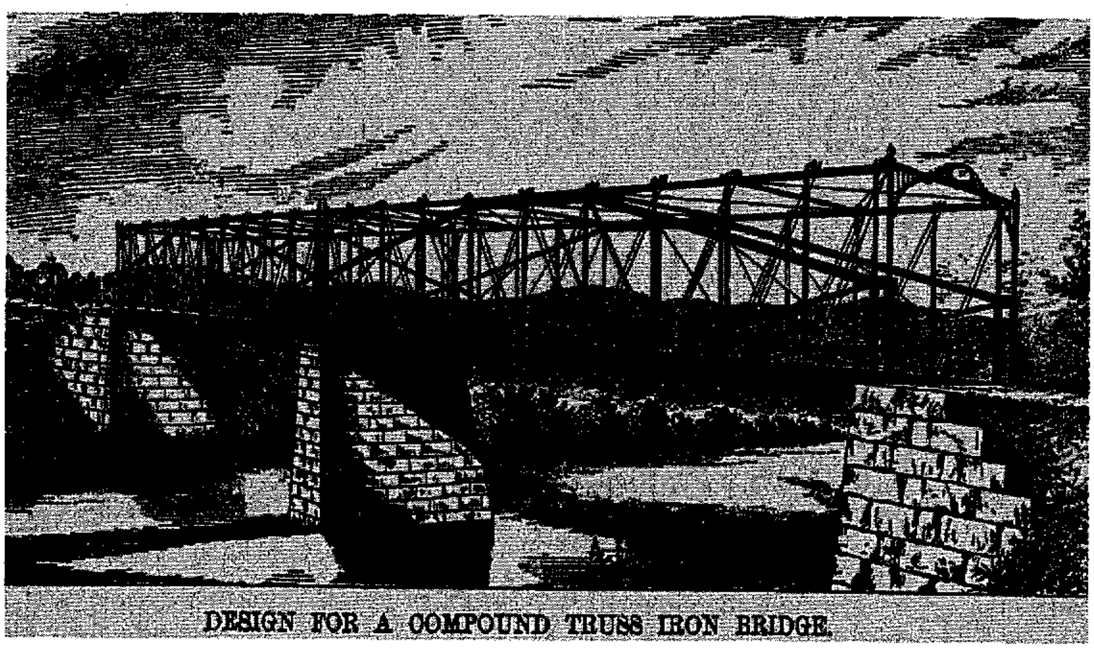

FIGURE 7.4 Suggestion for a compound truss bridge.
Source: Douglas (1877).

his patent application (March 28, 1878) by nearly eight months. This is the only known publication by Douglas or any other engineer associated with the Berlin Iron Bridge Company or its predecessor, the Corrugated Metal Company, related to the lenticular design during this era.

Douglas (1877) also suggested a "Compound" truss bridge as shown in Figure 7.4. At the end of his brief note, Douglas made a general appeal for comments "Criticisms of the general principles of this elliptical truss, positive and comparative, are respectfully invited from engineers over their signature". There are no published responses to Douglas's request in subsequent issues of *Scientific American Supplement.* At least one surviving bridge builder's plate (Depot Rd. No. Chichester, N.H.) indicates "Douglas & Jarvis Patents, April 16, 1878, April 5, 1885". There are no known patents related to the lenticular shape attributed to Jarvis.

BRIDGE PRODUCTION BY THE BERLIN IRON BRIDGE COMPANY

A number of the bridges had been built by the predecessor of the Berlin Iron Bridge Company, the Corrugated Metal Company, out of their small manufacturing plant located in Berlin, Connecticut. It appears that one of the first lenticular bridges by the Corrugated Metal Company was a four-panel Pony Truss bridge apparently built in 1879 and erected at Waterbury, Connecticut, spanning the Naugatuck River. This bridge is still standing and is in use as a vehicular bridge. The smallest of these bridges consisted of 3 panels, with a span of only about 40 ft. Bridges were built principally throughout the northeast, with surviving examples that still may be seen in Massachusetts, Vermont, New Hampshire, Rhode Island, Connecticut, New York, New Jersey and Pennsylvania. It is also known that several bridges were built in Ohio, but it seems that none survive. Interestingly enough, there are at least six extant lenticular truss bridges in Texas, the only ones known to have been sold and built west of the Mississippi River, and thought to have been the work of an extremely enthusiastic free lance salesman in Texas. There is no indication that any bridges were actually built with the simple configuration of Douglas's suggestion of 1877. A few short span 3 panel pony truss bridges do show some similarity to his drawing such as at Sharon Station, Ct., Hadley, N.Y. and Smithfield, R.I. The span lengths of these remaining three panel pony truss bridges are 40 ft., 44.5 ft., and 48 ft., respectively.

The name of the Corrugated Metal Company was changed to the Berlin Iron Bridge Company sometime around 1883 according to Darnell (1979) and, according to company literature, they provided almost 90% of the iron bridges roadway bridges throughout New England from 1880 to 1890. Designs for the bridges included both Pony Truss and Through Truss configurations. A second U.S. patent (No. 315,259) was granted to Douglas for improvements on his design on April 7, 1885. The primary improvements that Douglas incorporated into this patent were the use of floor line tension chords and strut braces. The strut brace was noted by Douglas to improve the bridges behavior under wind loading. The floor line tension chord was often simply a wrought iron rod running the length of the truss and connected to the end posts on either end. A turnbuckle was used to adjust the tension. Douglas's 1885 patent drawings show only his strut brace and floor line chord applied to a suspended deck bridge.

Figure 7.5 shows the typical bridge configurations used by the BIBCO at different locations. Most of the extant lenticular truss bridges are of the suspended deck style. There is only one mid-deck bridge and only two under deck spans known to exist. Figure 7.6 shows the various combinations of bridges used at different locations.

Douglas died around 1890, but the Berlin Iron Bridge Co. continued to be very productive under the leadership of several men. Early ads run by the company indicate the

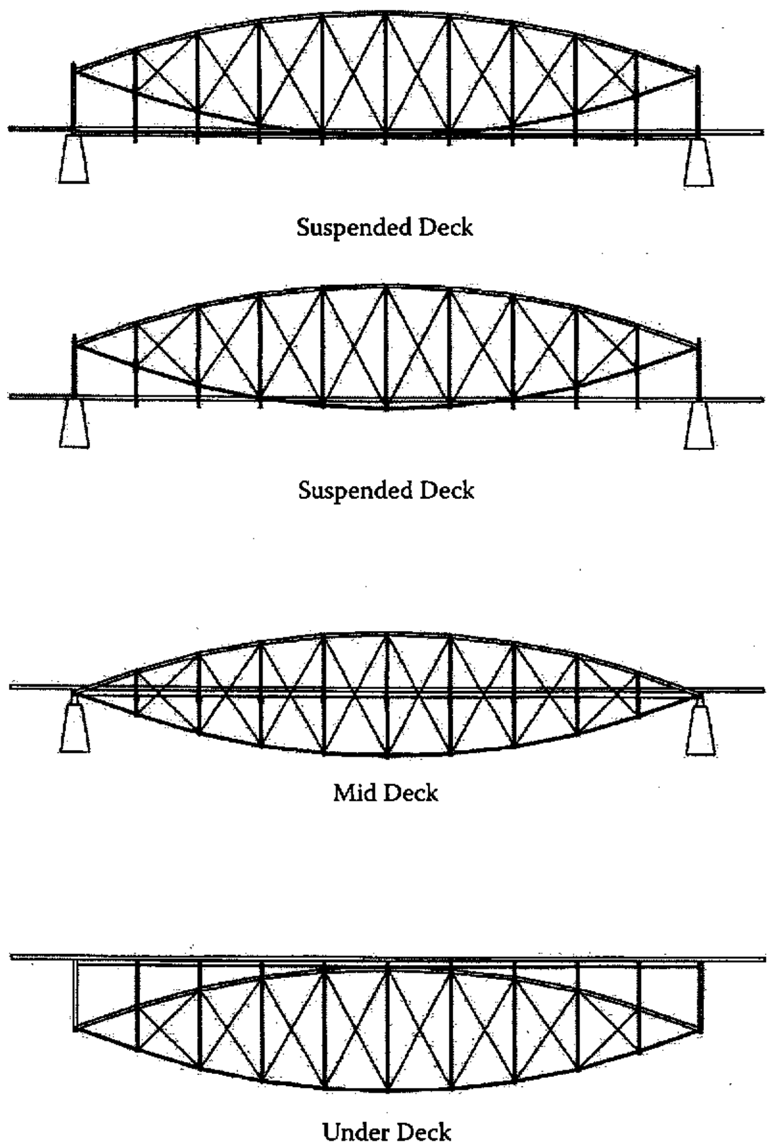

FIGURE 7.5 Bridge configurations constructed by the Berlin Iron Bridge Company.

following principals: Charles M. Jarvis, President and Chief Engineer; Mace Moulton, Consulting Engineer; Burr K. Field, Vice President; George H. Sage, Secretary; and F. L. Wilcox, Treasurer.

The Berlin Iron Bridge Company, under the leadership of Charles M. Jarvis, acquired the rights to Douglas's patent, which accounts for the exclusive promotion of this style of bridge by the company. Additionally, the company apparently had excellent salesmen or agents who were most likely paid on commission, many of whom may have had a special affinity to this style of bridge, especially since the company designed and built other more conventional truss bridges. No other lenticular bridges built by any other bridge manufacturer of the era are known to have been designed, built or even advertised. This style of bridge was unique to the Berlin Iron Bridge Company.

A number of textbooks available during the period from about 1870 to 1885 presented descriptions of this style of bridge, referred to at that time as "Double

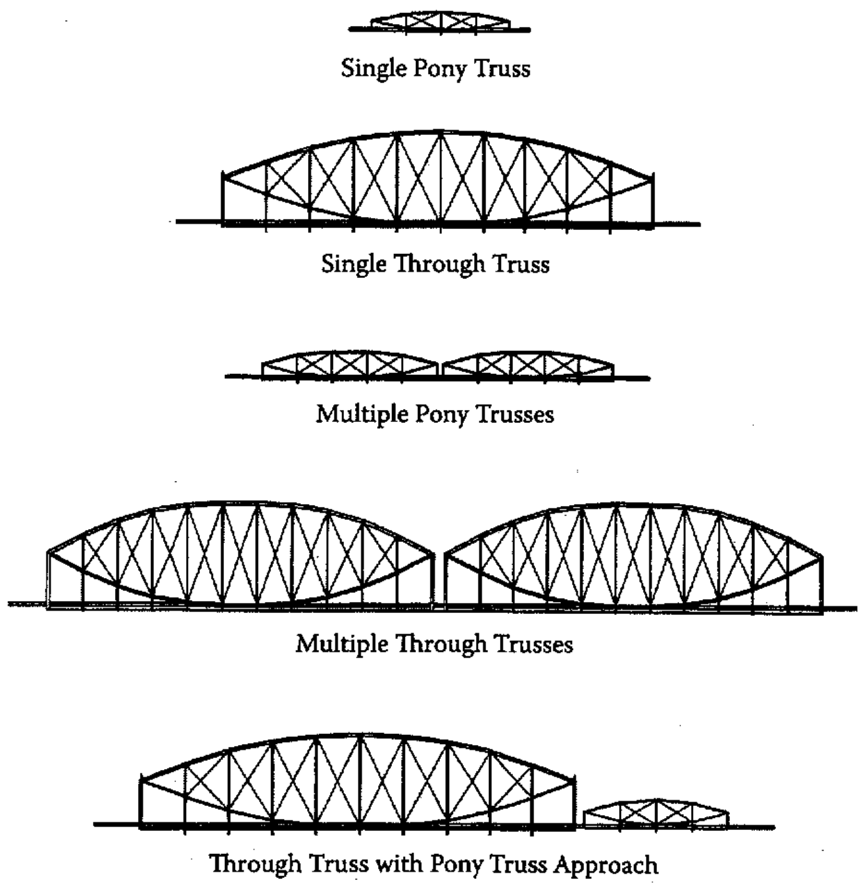

FIGURE 7.6 Different bridge combinations used at various locations.

Bowstring", "Parabolic", "Bowstring Suspended" or "Lenticular" bridges (e.g., Campin 1871; Matheson 1873; Shreve 1873; Rankine 1874; Ritter 1879; DuBois 1883). Even after the end of the 19th century and into the 1920s, the bridges were still discussed in some texts (e.g., Merriman and Jacoby 1906; 1920). In Chapter X of his book, Shreve (1873) provided an example of the design of a lenticular truss, described by Shreve as "The form of this peculiar truss, known also as the Pauli System…" noting that "It is not capable of supporting any greater weight than a Bow String Truss of equal depth and length, and practically possesses many disadvantages". DuBois (1883) shows a diagram of a lenticular truss with Warren style bracing noting that "the bracing may be of any sort" and also that "In Germany, this shape is known as the *Pauli* truss".

SUMMARY OF SURVIVING BRIDGES

Throughout New England and other parts of the U.S., there are a number of surviving lenticular bridges built by the Berlin Iron Bridge Co. A few have been restored; many are closed to traffic; some have been adapted for other uses, such as pedestrian bridges, while others have already been scheduled for replacement. A summary of the remaining lenticular truss bridges known to the author is given in Table 7.1. By far, the most common style of bridges produced in either the pony truss or through truss configuration were simple suspended deck bridges; these are represented most by the

TABLE 7.1
Extant Berlin Iron Bridge Company Lenticular Truss Bridges

No.	State	Town	No. of Panels	Span (ft)	Mid-Span Height (ft.)	Aspect Ratio, L/H
		Pony Truss Bridges				
1	Connecticut	Main Street, Talcottville	4	61	8	7.6
2		Washington Ave., Waterbury	5	67.5	8	8.4
3		Sheffield Street, Waterbury	4	53	8	6.6
4		Minortown Rd., Woodbury	4	63	8	7.9
5		W. Main Street, Stamford	5	60.5 (2)	10	6.0
6		Oliver Street, Stamford	4	53	8	6.6
7		Melrose Ave., E. Windsor	4	63	8	7.9
8		Oregon Rd., Meriden	5	78	8	9.7
9		Hallville Mill, Preston	4	60	6	10.0
10		Ashland Mill, Jewett City	4	65	6	10.8
11		Sharon Station Rd., Sharon	3	40	6	6.7
12		Sebethe Dr., Cromwell	N/A	N/A	N/A	N/A
13	Massachusetts	Golden Hill Rd., Lee	5	80	8	10.0
14		Pumpkin Hollow Rd.	4	58	8	7.2
15		Fort River, Amherst	4	60	8	7.5
16		Gilbert, Rd., Warren	5	72	8	9.0
17		Blackstone Bikeway	6	74	8	9.2
18		North Canal, Lawrence	5	83	8	10.4
19	New Hampshire	Delage Rd., Franconia	4	56	6	9.3
20		Dow Ave., Franconia	5	69	8	8.6
21	New Jersey	Cleveland Bridge, Mahwah	5	83	8	10.4
22	New York	Water St., Homer (east)	4	45	6	7.5
23		Water St., Homer (west)	4	52.5	6	8.7
24		Wall St., Homer	4	52.5	8	6.6
25		Pine St., Homer	4	58	8	7.2
26		Rhule Rd, Malta	5	71	6	11.8
27		Corinth Rd., Hadley	3	44.5	6	8.9
28		Silk St., Newark Valley	5	69	8	8.6
29		Avoca (Wallace)	4	51	N/A	—
30		Niobi Junction	3	N/A	N/A	—
31		Long Lane Road, Steuben Co.	4	N/A	N/A	—
32	Pennsylvania	S. High St., Duncannon	5	81	8	10.1
33	Rhode Island	Stillwater Rd., Smithfield	3	48	6	8.0
34		Interlaken Mills, Arkwright	6	91	11.33	8.0
35	Texas	Augusta St., San Antonio	7	98	22.2	4.4
36		Crockett St., San Antonio	6	84	13.7	6.1
37		S. Presa St., San Antonio	7	98	13.7	7.2
38		Soda Spring Rd.	5	75	8	9.4

TABLE 7.1 (continued)
Extant Berlin Iron Bridge Company Lenticular Truss Bridges

No.	State	Town	No. of Panels	Span (ft)	Mid-Span Height (ft.)	Aspect Ratio, L/H
		Pony Truss Bridges (continued)				
39		Salado	6	87	8	10.9
40		Kelley Crossing, Caldwell Co	6	89	12	7.4
41	Vermont	Randolph Rd., Bethel	4	58	8	8.2
42		Highgate Falls	5	68.75	8	8.6
		Through Truss Bridge				
43	Connecticut	Brunswick Ave, Plainfield	8	124	19	6.5
44		Main St., Moosup	7	105	19	5.5
45		Lover's Leap, New Milford	10	172.5	30	5.8
46		Boardman's Rd., New Milford	13	188	30	6.3
47	Massachusetts	Galvin Rd., N. Adams	7	103	18	5.7
48		Bardwell's Ferry Rd., Shelburne	13	198	30	6.6
49		Aiken St., Lowell	11	153 (5)	32.8	4.6
50	New Hampshire	Depot Rd., N. Chichester	6	95	19.66	4.8
51	New Jersey	Neshanic Station	9	140.5 (2)	23.0	6.1
52	New York	Kelsey St., Candor	5	69	16.33	4.2
53		Ouaquaga, Colesville	8	170 (2)	30	5.7
54		Washington St., Binghampton	10	170 (3)	30	5.7
55		Taylor Town Line Rd.	6	82.5	17.33	4.8
56		Delhi	8	114.5	20.5	5.6
57		Walton Bridge, Keene	N/A	N/A	N/A	—
58	Texas	Yancey Rd., Frio Co. (now Santa Cruz Ranch)	7	109	19.83	5.5
59		Brackenridge Park, San Antonio	7	92.75	23	4.0
60	Pennsylvania	Pierceville, Nicholson Township, Wyoming Co.	8	113.83	16	7.6
61	Vermont	Highgate Falls	13	214.5	30	7.1
		Through Truss—Warren Configuration				
62	New York	Raymondville	9	288	36.5	7.9
63	Pennsylvania	Jersey Shore, Lycoming Co.	14	287	39.66	7.2
64		Waterville, Lebanon Co	12	220.75	33	6.7
		Half-Deck				
65	New York	Corinth Rd., Hadley	9	136	18	7.6
		Under Deck				
66	New Hampshire	Livermore Falls, Compton	10	138	30.2	4.6
67		Livermore Falls, Compton	7	101.5	14	7.2

Note: Number in ( ) indicated number of spans.

extant bridges. Of the known bridges at this writing, there are a total of 43 pony truss bridges, a total of 27 through truss bridges, three through truss bridges with Warren bracing, one mid-deck bridge and two under deck bridges. While a complete analysis of the variations of all the different bridge components is beyond the scope of this paper, a number of initial observations may be made for both pony truss and through truss bridges. The Texas bridges are not discussed in this paper as they are considered by the author as a unique set of bridges, especially those in San Antonio.

ANALYSIS OF SURVIVING BRIDGES

Aspect Ratio (L/H)

Included in Table 7.1 is the measured span length of each bridge, taken as the distance between center of pins on the end posts, and the mid-span height of each bridge, taken as the distance between pins on the center vertical hanger. The aspect ratio of the bridges, taken as the span length/mid span height (L/H), is also given. The aspect ratio of the pony truss bridges ranges from about 6 to 11 and is dictated by the fact that the maximum height at mid-span of any of the bridges is only 10 ft. This gives the pony truss bridges the appearance of a long and slender span. Nearly all pony truss bridges have either a 6 ft. or an 8 ft. vertical post at mid-span, which appear to be standard components used by the Company. The 6 ft. posts were often used on bridges with a mid-span post of 8 ft. The 6 ft. and 8 ft. vertical web posts occur in both a tapered configuration and a parallel configuration as will be discussed. Other pony truss bridges appear to represent special designs; these include the twin spans of West Main Street in Stamford, Ct., the Interlaken Mills Bridge in Arkwright, R.I and the Kelley Crossing Bridge in Texas. The latter two bridges are nearly identical bridges of the "half through" design; that is, with the deck supported above the tangent horizontal line to the lower chord. These are the only known examples of this style bridge to survive. All four of these spans have a higher mid-span height as compared to all of the other pony truss bridges.

Figure 7.7 shows a plot of the aspect ratio as a function of the span length for all pony truss bridges, including those located in Texas. Since most of the bridges throughout the northeast are what can be considered as a standard design and have either a mid-span web post of either 6 ft. or 8 ft. in height, it can be seen that the aspect ratio increases linearly with span length. Two of the Texas brides (Soda Spring Rd. and Salado) were essentially designed like all of the bridges in the northeast and fit into the lower linear trend line. The other four Texas bridges, all of which are located in San Antonio, show individual unique configurations. They are among the longest of the pony truss bridges constructed and they have relatively large mid-span heights. There is considerable overlap in the two linear trend lines which results from designers using both 6 ft. and 8 ft. mid-span web posts on bridges of the same span length. The transition is essentially from 3 to 4 to 5 panels for all the standard designs. Outside of Texas, there are only 2 known pony truss bridges with more than 5 panels.

The aspect ratio of the through truss bridges ranges from 4 to about 8 for span lengths ranging from 69 ft. to 215 ft. This gives many of the through truss bridges a more rounded "elliptical" shape when viewed from the side. Figure 7.8 shows the

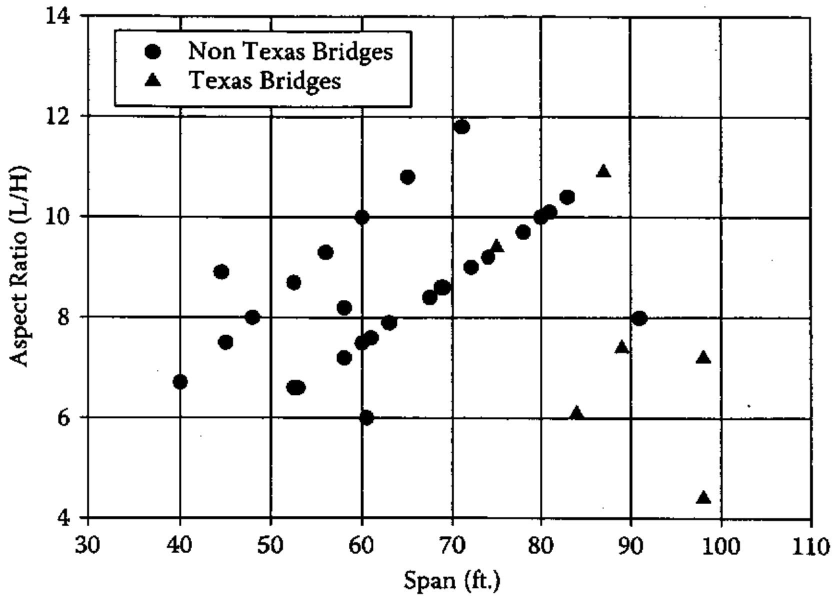

FIGURE 7.7 Relationship between span length and aspect ratio—pony trusses.

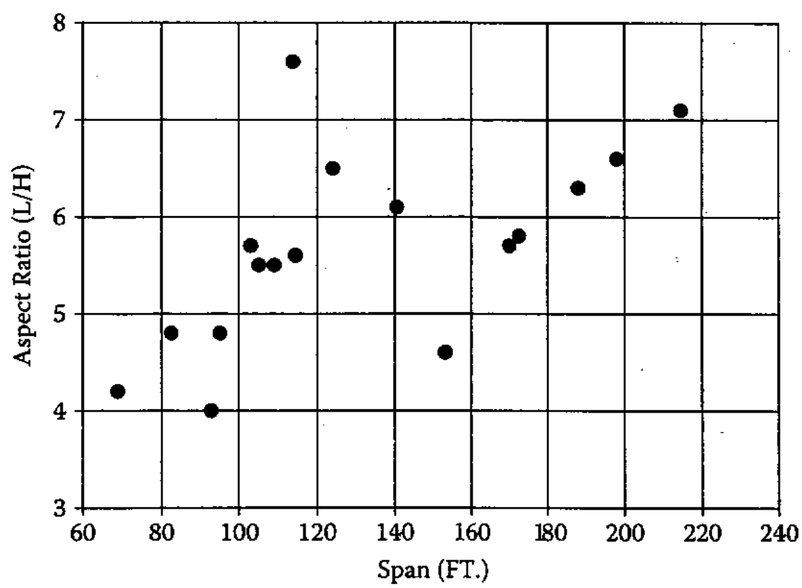

FIGURE 7.8 Relationship between span length and aspect ratio—through trusses.

variation of aspect ratio with span length for all of the through truss bridges (not including the three Warren configurations). There appears to be considerably more scatter in these dimensions than in the pony truss, especially in the shorter span lengths, from about 69 ft. to 120 ft. It is possible on the longer span bridges, i.e., after about 150 ft. that designers started to use a fixed maximum mid-span height of 30 ft.

Number of Panels

Figure 7.9 shows the variation in the number of panels used in the construction as a function of the span length for both pony truss and through truss bridges (not including Texas bridges or Warren bridges). The overlap is more apparent in the pony truss

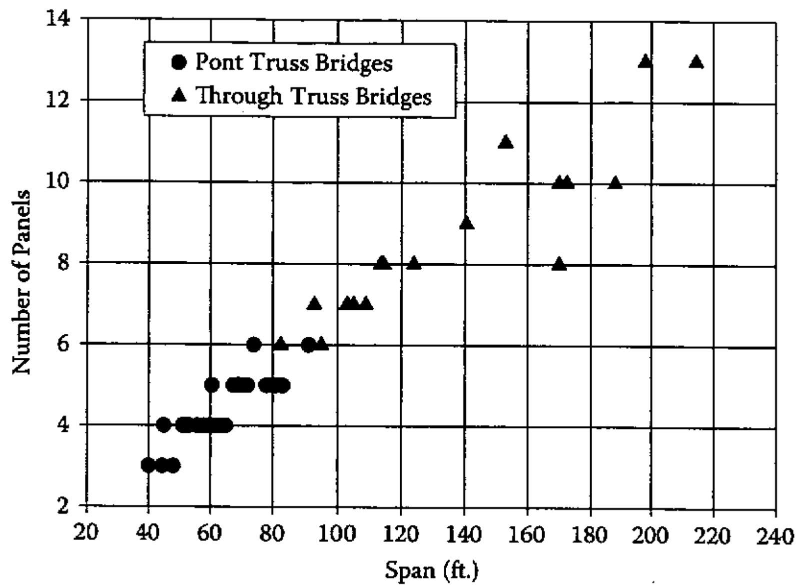

FIGURE 7.9 Variation in number of panels as a function of span length.

designs. As the required span length increased designers simply extended the existing panels in some cases while in other cases they added a panel.

Vertical Web Posts

Vertical web posts used on the pony truss bridges to connect the upper and lower chords are the simplest of all of the built-up members and were fabricated from four angle sections with riveted flat bar diagonals. Web posts were either tapered or were constructed with parallel sides as shown in Figure 7.10. Tapered web posts were connected to the pins at the upper chords on the inside of the chord, while parallel web posts were connected to the upper chords on the outside of the chord. It appears that these components for suspended deck pony truss bridges were mass produced to a standard configuration at the East Berlin plant and then the geometry of other components were adjusted to fit the required span length needed at individual sites.

For example, not including the Texas bridges which appear to be unique unto themselves, essentially all pony truss bridges used vertical posts with a maximum fixed length of 8 ft. Regardless to the number of panels used to assemble the full span, vertical posts of 8 ft. and 6 ft. were almost exclusively used to produce 3, 4, and 5 panel bridges with span lengths ranging from 40 ft. to 83 ft., as indicated in Table 7.1. The ends of the top chords could have easily been adjusted to give the appropriate length and connecting angle so that riveted plates would fit properly between chord members. This means that the vertical posts could be assembled and placed in inventory until the other components were fabricated. Since the bottom chord of all bridges consisted on wrought iron flat eye bars, their lengths could also have been easily adjusted to fit the specific location. Table 7.2 gives a summary of the pony truss bridges with these two variations. There are nearly twice as many bridges fitted with tapered web posts as compared to parallel web posts. This variation appears to be only the result of the selection by the buyer who opted for either parallel or tapered web posts for purely aesthetic reasons.

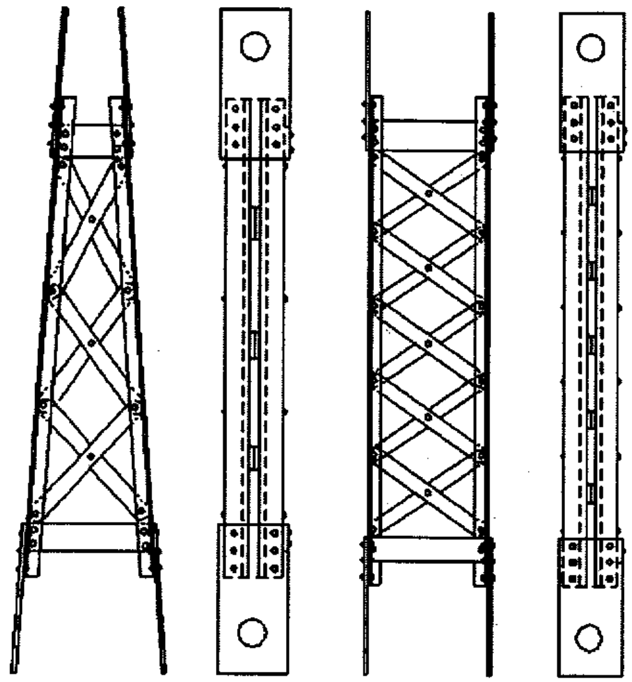

FIGURE 7.10 Vertical web post variations used on pony trusses.

End Post—Lower Chord Connections

On pony truss bridges, the connection between the end post and the top chord was made using a special cast iron connector with the lower chord extending through and then held with a nut. A comparison of these two styles of end post-top chord connections is shown in Figure 7.11. Table 7.3 gives a summary of the remaining pony truss bridges with different end post connections for the upper and lower chords. The use of both end post configurations appears to be about equal. There does not appear to be any preference on connection type with age, that is both early and late bridges show both types of connections, and there is no trend with either span or number of panels. The choice on end post connection appears completely random at this time.

Lower Eye Bar Chords

Wrought iron eye bars used as lower chords show the widest variation of any members used on both the pony truss and through trusses. The different size eye bars used are summarized in Table 7.4. All pony truss bridges and nearly all through truss bridges used only pairs of eye bars on the lower chords (the exceptions are the 5 spans of the Aiken St. Bridge in Lowell Mass which carry two lanes of traffic and pedestrian walkways; three spans of the So. Washington St. Bridge in Binghampton, N.Y., and the Bardwell's Ferry Bridge in Shelburne, Ma.). Figure 7.12 shows the relationship between the total cross sectional area of the lower chord eye bars and the span length for both Pony Truss and Through Truss Bridges. While there appears to be considerable scatter in these observations, a more detailed review is needed to isolate those bridges which also were constructed with either single or double walkways, which increase the dead load of the bridge.

TABLE 7.2
Summary of Pony Truss Bridges with Tapered and Parallel Web Posts

Tapered Web Posts	Parallel Web Posts
Main Street, Talcottville	Minortown Rd., Woodbury
Melrose Ave., E. Windsor	Washington Ave., Waterbury
W. Main Street, Stamford (2)	Sheffield Street, Waterbury
Oliver Street, Stamford	Sharon Station Rd., Sharon
Oregon Rd., Meriden	Golden Hill Rd., Lee
Ashland Mill, Jewett City	Fort River, Amherst
Hallville Mill, Preston	Dow Ave., Franconia
Pumpkin Hollow Rd.	Corinth Rd., Hadley
Gilbert, Rd., Warren	Water St., Homer (east)
Blackstone Bikeway	Water St., Homer (west)
North Canal, Lawrence	Wall St., Homer
Delage Rd., Franconia	Pine St., Homer
Cleveland Bridge, Mahwah	Niobi Junction
Rhule Rd, Malta	
Silk St., Newark Valley	
Long Lane Road, Steuben Co.	
Wallace	
S. High St., Duncannon	
Arkwright Mills	
Stillwater Rd., Smithfield	
Highgate Falls	
Randolph Rd., Bethel	

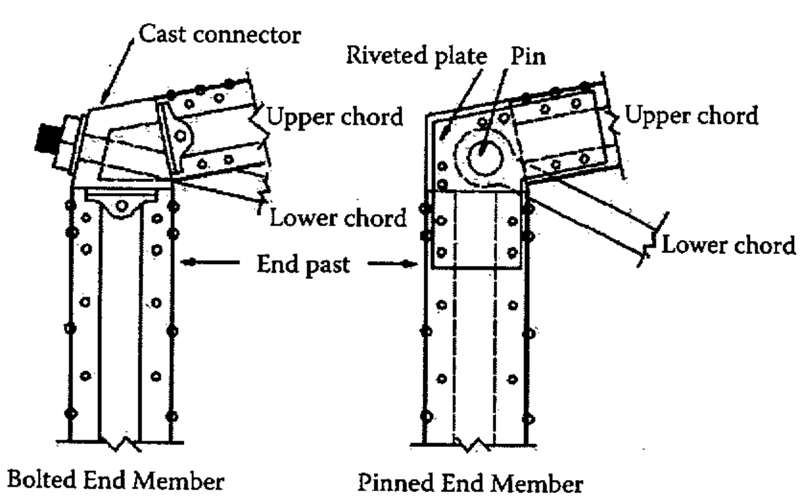

FIGURE 7.11 Variation in end post connections used on pony truss bridges.

TABLE 7.3
Summary of Different End Connections used on Pony Truss Bridges

Bolted Lower Chord End Connection	Pinned Lower Chord End Connection
Minortown Rd., Woodbury	Main Street, Talcottville
Melrose Ave., E. Windsor	Washington Ave., Waterbury
Hallville Mill, Preston	Sheffield Street, Waterbury
Ashland Mill, Jewett City	W. Main Street, Stamford (2)
Sharon Station Rd., Sharon	Oliver Street, Stamford
Pumpkin Hollow Rd.	Oregon Rd., Meriden
Gilbert, Rd., Warren	Golden Hill Rd., Lee
Delage Rd., Franconia	Fort River, Amherst
Dow Ave., Franconia	Blackstone Bikeway
Rhule Rd, Malta	North Canal, Lawrence
Corinth Rd., Hadley	Cleveland Bridge, Mahwah
Silk St., Newark Valley	Water St., Homer (east)
Long Lane Road, Steuben Co.	Water St., Homer (west)
Stillwater Rd., Smithfield	Wall St., Homer
Highgate Falls	Pine St., Homer
	Water St., Homer (east)
	Niobi Junction
	S. High St., Duncannon
	Randolph Rd., Bethel

SUMMARY

An inventory of the extant lenticular iron truss bridges manufactured by the Berlin Iron Bridge Company in East Berlin, Connecticut has been developed and is being used to provide some clues into the designs used by the Company. Comparisons of the geometries of the various components used at specific locations are being performed to provide a basis using "as-built' configurations. Only some initial comparisons have been made at this writing; more detailed evaluation is needed. Using the documentation developed by observations made on the extant bridges along with other documentation in HAER on bridges that have been lost, it is hoped that a more detailed picture of the design of these unique bridges will be possible.

As far as is known, there is no single complete list of lenticular bridges built by the Company; however, a partial list is currently being prepared by the author using a catalog of the Corrugated Metal Company (graciously provided by Mr. William Chamberlain), the list of bridges published by Darnell (1979), the author's personal copy of the Berlin Iron Bridge Company promotional catalogue circa 1890; various advertisements published in period trade journals and magazines; the author's personal collection of period postcards; the scant references available in the technical literature, and the list of extant bridges given in Table 7.1.

TABLE 7.4
Summary of Variations in Lower Chord Eye Bars

No. of Lower Eye Bars	Eye Bar Dimensions	Section Area (in.^{2})	Bridge
	Pony Truss Bridges		
2	3⁄4 in. × 2 in.	1.5	Water St. (east)
2	3⁄4 in. × 2 1⁄2 in.	1.875	Minortown Rd. Melrose Ave. Corinth Rd.
2	1 in. × 2 in.	2	Fort River Wall St. Homer
2	1 1/16 in. × 2 in.	2.125	Water St. (west)
2	3⁄4 in. × 3 in.	2.25	Talcottville Oliver St.
2	1 1/2 in. × 1 1/2 in.	2.25	Bethel
2	1 in. × 2 1⁄2 in.	2.5	Washington Street Sheffield St. Hallville Mills Silk Street Ruhle Rd.
2	7/8 in. × 3 in.	2.625	Ashland Mill
2	1 1/8 in × 2 1⁄2 in.	2.8125	Pine St. Homer Smithfield
2	1 in. × 3 in.	3	Oregon Rd. Golden Hill Rd. Pumpkin Hollow Gilbert Rd. Blackstone Bikeway Highgate Falls
2	1 in. × 3 in. & 2 in. × 3 1⁄4 in.	36.5	Dow Ave.
2	3⁄4 in. × 4 in.	3	Delage Rd.
2	1 in. × 3 5/8 in.	3.625	Arkwright Mill
2	1 3/16 in. × 3 1/8 in.	3.71	Mahwah
2	1 3⁄4 in. × 3 in.	3.75	Duncannon
2	1 in. × 4 in.	4	W. Main St., Stamford North Canal, Lawrence
	Through Truss Bridges		
2	3⁄4 in. × 2 1⁄2 in. & 1 in. × 2 in.	1.8752	Taylor Town Line
2	7/8 in. × 2 1⁄2 in.	2.1875	Kelsey Street
2	3⁄4 in. × 3 in.	2.25	Santa Cruz Ranch Main St. Moosup

TABLE 7.4 (continued)
Summary of Variations in Lower Chord Eye Bars

No. of Lower Eye Bars	Eye Bar Dimensions	Section Area (in.^{2})	Bridge
	Pony Truss Bridges (continued)		
2	1 in. × 3 in.	3	DelhiGalvin Rd. Chichester
4	1 in. × 3 in.	3	Bardwell's Ferry
2	1 1/8 in. × 3 in.	3.375	Pierceville
2	1 1/4 in. × 3 in.	3.75	Brunswick Ave.
2	1 in. × 4 in.	4	Ouaquaga
4	1 in. × 4 in.	4	South Washington St.
2	1 1/2 in. × 3 in.	4.5	Neshanic Station
2	1 1/8 in. × 4 in.	4.5	Boardman's Bridge
2	1 1/4 in. × 5 in.	6.25	Brackenridge Park Lover's Leap
4	1 5/8 in. × 4 in.	6.5	Aiken St.
2	1 3/8 in. × 5 in.	6.875	Highgate Falls

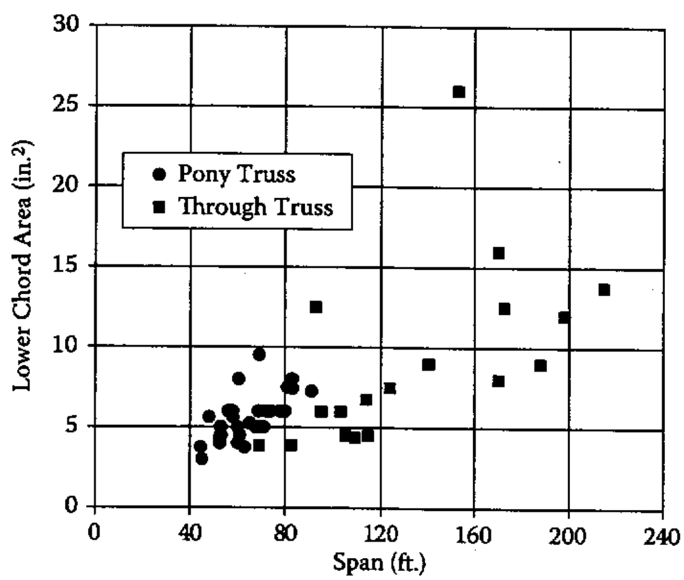

FIGURE 7.12 Relationship between lower chord area and span length.

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