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December 4, 2021

The Sanborn Covered Bridge

Lyndonville, Vermont

A Preservation Trust of Vermont

Technical Assistance Survey

The Sanborn Bridge is a covered Paddleford Truss built in 1869 across the Passumpsic River in Lyndonville. In 1959 it was moved by the noted covered bridge restorer Milton Graton to its current location across the West Branch of the Passumpsic river at the north edge of Town. The total length of the truss is 118 ft. and the clear unsupported span between 100 and 108 ft., depending upon how it is measured.

The Paddleford Truss was designed by Peter Paddleford of Littleton, NH, probably around 1846. It was never patented but was in wide use during the 2nd half of the 19th century in Northeastern Vermont, northern New Hampshire and Western Maine. The Paddleford is a form of Multiple kingpost truss with the main braces in compression and any individual counterbrace acting in tension by means of their crossing, and being joined to, both top and bottom chords, two sequential posts and their two main braces. The main braces and counterbraces run diagonally opposite each other. (see sketch)

The Sanborn trusses are each composed of 14 panels, 7 ft. 7 in. center to center, with two 6 ft. panels which are over the abutments. These trusses have sophisticated engineering refinements such as an increase in size of the columns from the center to the ends, beginning at 7 ½ x 9 towards the center and increasing to 9 ½ x 9 at the abutments. The main braces also increase in size from midspan to the abutments, joining the columns in reflecting the increased load they accumulate over the distance. The counterbraces remain as 4 x 6's everywhere. The top chord, clasping the column is composed of two 3 ½ x 10's on in the inside and a single 5 x 10 on the exterior. These are joined to each other occasionally by 1 ½ inch wooden pins and shoulder into the posts. The bottom chord is composed of pairs of 3 ½ x 12 inch timbers shouldered into the columns on either side. The bottom chord, since it is in tension (as opposed to mostly compression in the top chord) has both pins and wooden shear blocks joining each lamina and the pairs of lamina.

The floor system of the bridge is 18 ft. wide between the trusses, producing a double lane bridge and the possibility of a lot of live load in the past as well as a lot of self weight. The floor system is one layer of 3 inch deck plank supported by variously 3, 4 and 6 x 12 inch joists no more than one foot apart. There is no underfloor diagonal bracing and likely no need for any as the spiking of the floor to that many joists produces a rather rigid diaphragm. The joists are lodged right on top of the bottom chord.

The overhead bracing of the truss is far better than that of most covered bridges. 8x8 x 20 ft. tie beams are tenoned and pinned to the top of each post. The rafters in turn are birds mouthed and tenoned onto the extended tie beam ends. These rafters continue to carry 5 ft. strutted and cantilevered eaves and serve to add all this roof weight and stiffness to the upper level of the two trusses. Over the roadway there are long crossing horizontal diagonal braces tenoned into the ties as well as knee braces. These overhead and floor systems have kept the Sanborn in a relatively straight line, in spite of the fact that both trusses are very sagged and the downstream bottom chord was broken to discontinuity for a number of years until repaired recently.

Where the bridge hits the abutments it is supported on 12 x 12 cantilevered bed timbers between the bottom chords and a concrete beam. The bed timbers are both sacrificial, i.e. to themselves rot rather than the bottom chord, and to spread the load and slightly reduce the span.

The abutments are rather good and very old fieldstone masonry with a less good concrete beam poured on top, suffering from ground and drainage problems.

The upstream side of the Sanborn Bridge carries a cantilevered walkway that came with it from its previous location. It is supported on joists that lodge atop the bottom chord and attach to the roadway joists.

In spite of the many excellences of its construction, the bridge is imperiled and suffers from certain defects, both as a result of being damaged by ice and debris in the river, and some from its original design.

First: The majority of the column bottoms, as well as the counterbrace extensions, both of which carry the bottom chord in tension, have been either broken off entirely or damaged by ice and debris. These same environmental effects have ground away at the upstream bottom chord and changed its shape and reduced its section. At most locations pairs of 5/8 in. steel rods, dropping from the top chord parallel to columns, are adding crucial assistance to the damaged posts in carrying the bottom chord.

Photographs from the moving of the bridge in 1959 (some in the hands of the Lyndon Historical Society, others in Milton Graton's book **The Last** of the Covered Bridge Builders (1978)) show the bridge with its column bottoms intact and only a bit of sag in the trusses. At its previous location it stood higher above the river.

Secondly: The Sanborn truss was only marginally capable, as built, of supporting its span, the wide roadway and traffic, and the extended roof and walkway. The shouldering of the main braces 3 inches into the columns, top and bottom, produced a weakness resulting in the first 2 or 3, more heavily loaded, columns at each truss end to distort and break under the load delivered by the main braces. A bridge of this span and weight would have profited from even larger columns, check bracing behind the columns, or a double posted design. In addition, the bottom chords are suffering localized bending in the areas of the overloaded posts.

A further problem is the bad location of the current bearing of the bottom chords on the abutments, putting maximum loads in the midspan of the panels rather than right behind a column position.

The Bridge looked to be doing reasonably well in 1959, flat or with slightly negative camber, but probably couldn't accommodate any loss of structural integrity such as the post bottoms and failures in the bottom chord.

The Sanborn Bridge is roofed in old, galvanized sheet metal on purlins, not obviously leaking.

The sidewall boarding, both now and in 1959, is only breast height. The 5 ft. overhanging eaves are expected to shelter the trusses from moisture.

The Sanborn is an ambitious and elegant example of the Paddleford Truss, but is endangered by both being too low to the river and its own structural problems. If not for the emergency stabilization carried out by Tim Andrews and the National Society for the Preservation of Covered Bridges in 2014-2015, it may have collapsed. It is one of only two historic Paddlefords left in Vermont and a handful elsewhere.

Sanborn Covered Bridge: Maintenance and Restoration

1. Framing: The Trusses: The trusses are what enable the bridge to span the Passumpsic River and are thus our major concern. Even with damage from ice, flooding, and water infiltration through the side walls and roadway runoff at both ends, the Sanborn has managed to sustain its span for 152 years. However, more than just needing repairs, this Bridge suffers from a condition common to many long span trusses, i.e. the progressive distortion and deterioration (even without wood rot) of the heavily loaded columns and chord members as its accumulated load approaches the abutment. This problem was noted by Ithiel Town (designer of the Town Lattice Truss) in the early 19th century, and was recognized by the builders of the Sanborn when the chose to increase both column and main brace dimensions progressively from mid span to each end.

In addition to the deterioration by load described above, there is the fact that almost every upstream column and counter brace, and many of those downstream have been broken by ice and flood debris in the past. The

downstream chord had at some point rotted completely through and was repaired well, but with temporary intent, in 2014-15. The upstream chord has been ground by ice to an odd, reduced shape. All of this suggests that the Sanborn Bridge needs to be removed from the river, and the trusses dismantled and rebuilt and even strengthened.

There are different possible ways to move the bridge to dry land where it can be worked upon:

One is the method the Gratons used in 1959; building a false bridge under the bridge and rolling it off the river. This might involve a couple of piers in the water and large steel beams spanning between them and the hope that no high water occurs while carrying this out.

A second involves the use of a very large crane to pick the bridge as one and remove it. This is possible but size of the crane will have to be immense due to the long reach, and the rigging will be complicated due to the weakness of parts of the bridge.

A third way is to remove the roof system, which is in good condition and reusable as is, including the overhead tie beams, possibly in two or three segments, by crane. Then, if the floor system of the bridge is supported briefly from at 2 or 3 points, the rest of the bridge can be dismantled and taken away piece by piece, or in segments, to be replaced or restored.

Following these or some other method of removal and dismantling, the trusses can be rebuilt using even larger posts at the first three positions out from each abutment. The current posts, reaching a maximum size of 9 ½ x 9 inches at the first post past the abutment might be changed to 12 x 9 inches and made of a stronger species such as hardwood or Southern Yellow Pine or Douglas Fir. In addition, the bottom chords, at least for their first thirds beyond the abutment can be increased in size to 16 inch deep material in as long lengths as possible. This deeper chord is accommodated by the fact that most of the columns and counterbraces are being changed anyway. A effective scheme of shear blocking, pinning, bolting and dapping the lamina at the columns can be devised.

The top chord material can mostly be reused at size unless some deterioration is discovered while dismantling. The excellent roof system should be reusable as well.

The rebuilt trusses can be stood up when completed, engaged with a floor system, have the roof system put back on, and the entire ensemble boarded and roofed on dry land, then repositioned over the river again by some difficult and expensive means.

2. **Abutments and Bed Timbers:** The stone and moreso the concrete abutments are in poor condition and need to be reconfigured to get the bridge higher above the river. If the Bridge were lifted 2 or 3 feet higher a number of purposes would be served.

First, ice and debris would almost never hit it because any flooding would have spread into the surrounding fields by that point.

Secondly it would make possible the cantilevering of a bed timber, or concrete cantilever, approximately 2 ft. deep that would cause the trusses to spring from immediately behind the first major column, and thus avoid bending and damaging the bottom chord.

The choice of raising the bridge and cantilevering additional support from the abutment will need the consultation and approval of State of Vermont flood plain management officials. However, the act of lifting the bridge significantly higher above the river should render this less difficult.

A side effect of elevating the bridge above the flood is that it will have to be approached by more of a ramp than is currently present for snowmobile, bike and pedestrian access. These ramps will probably need open spandrels underneath to allow flood waters to pass under rather than destroying them.

The abutments to the restored Sanborn should be new due to the poor condition of those existing. They can be made of concrete, fieldstone or large granite blocks. Even though stone foundations and bridge abutments have successfully performed for 1000's of years, far outperforming concrete, you will be fortunate to find any modern engineer willing to specify such a beautiful construction.

3. Floor System: It is hard to understand why a floor system of relatively small joists of variable quality(and spanning 18 ft.) spaced so closely, at 12 inches o.c.) would be built, but the answer may be that it wasn't built that way. Rather, smallish joists were used to maintain headroom on the bridge and just more were added all the time as vehicle loads increased. The

original floor system may have been completely different. If tall vehicles are never to use the Bridge again, a new floor system can be composed of larger joists spaced as wide as 3 ft. apart with a 3 or 4 inch plank floor, and a running surface on top for snowmobiles.

4.Roofing: The roof system composed of tie beams, wind and lateral bracing, rafters, purlins and struts is in good condition except possibly at the portals. A metal roof is the lightest weight covering and sheds snow loads the best and would be a good choice. The roof is not boarded but is just affixed to the purlins.

5. **Sidewall Boarding:** The sidewalls of the Sanborn are only boarded to slightly above waist height. This affords nice views and is no real problem because of the extensive roof overhang. This boarding can be two layers of vertical softwood boards with an outward sloping rail on top.

6. Sidewalk: If the Bridge is not going to be used for vehicles other than snow machines and bicycles, the sidewalk can be removed, although the roof overhang should be maintained, and the Bridge boarded to half height along the truss.

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Sanborn Covered Bridge: **Cost Estimates**

1. Framing: The Trusses: Remove the Bridge from the river. Dismantle everything but the roof system. Rebuild the trusses with enhanced capacity at certain points. Use the same style of joinery and connectors as in the original. Replace across the river.

Cost: $950,000

2. Abutments and Bed Timbers: Rebuild the abutments higher. Cantilever large dimension bed timbers. Construct access ramps.

Cost: $380,000

3. Floor System: 5 x 14 or similar capacity joists 3 ft. o.c with 4 inch plank flooring.

Cost: $110,000

4. Roofing: New galvanized steel.

Cost: $40,000

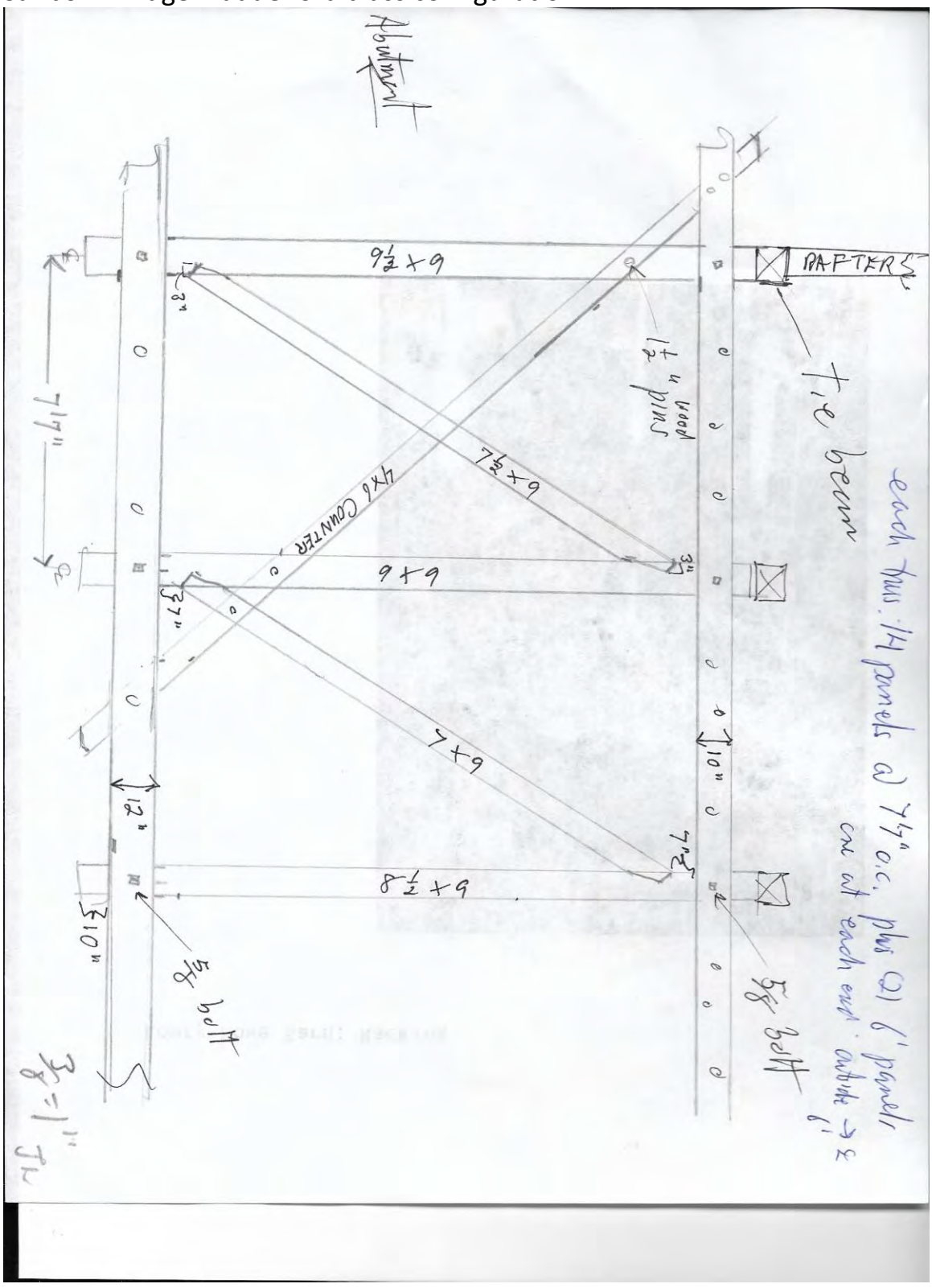
5. Sidewall Boarding: 2 layers of waist high 1 inch boards:

Cost: $15,000

6. Sidewalk: Remove at little cost beyond disposal.

Sanborn Covered Bridge, Lyndonville, Vt. from
Downstream

Sanborn Bridge: Paddelford truss configuration



Sanborn Bridge: Abutment concrete forms, crushing bed timber and bottom chord

Sanborn Bridge: broken and displaced post bottom near abutment

Sanborn Bridge: post bottoms

Sanborn Bridge:

Sanborn B ridge: 2014-15 downstream bottom chord repair

Sanborn Bridge:

Sanborn Bridge: and post.