The Vermont Bridge at Old Sturbridge Village

A Simplification of Earlier Work

An Interactive Qualifying Project Report

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Abstract

The objective of this project was to evaluate and simplify two earlier attempts to explain the history and technology of the Vermont Bridge at Old Sturbridge Village. This project focused on taking the information presented in the earlier reports and condensing it in to a form that was easily understood by the public. The information presented will be used in further enhancing the experience of the museum patrons.

Purpose

The purpose of this project was to simplify earlier IQP work in to a format that would be easily understandable to the public. The focus was to generate signage that would allow the presentation of this information at Old Sturbridge Village.

It is important to maintain focus on the mission of the village. The information presented to the public at this living museum must be in a format that allows visitors to find meaning, pleasure, relevance, and inspiration. This report as well as the signage that will follow is to advance the mission of the museum in a way that allows all visitors to appreciate the historical and technical significance of the Vermont Bridge.

The Vermont Bridge at Old Sturbridge Village, as well as other bridges from the same time period, played an important part in the rise of commerce and manufacturing in the United States. The advancements in technology that resulted in the designs of these bridges echoed the advances in agriculture, and transportation. The bridges also lead the way for increased urbanization. These advancements changed the everyday lives of New Englanders.

Literature Review

While the basis of this project involved reviewing and simplifying the research that the previous two groups had collected, it is also necessary to refer to some of the documents that were referenced. It was found that much like in the previous reports, that although there are many books and articles pertaining to covered bridges very few serve to provide accurate historical or technical accounts.

The libraries that were used by all three papers include Gordon Library at WPI, the research library at Old Sturbridge Village, and the American Antiquarian Society in Worcester. Among these libraries, several resources greatly influenced the progress of the paper. The works of Sloane, Condit and Allen provided an accurate account of the materials and procedures that would allow a bridge of this style to be built. Within the research library, there is a copy of Haupt's General Theory of Bridge Construction, which outlines a method of analysis for truss bridges. A copy of a brochure by Ithiel Town was also found at the Old Sturbridge Village research library; this document was an advertisement that was published to aid Town in the sale of his bridge design.

History of the Vermont Bridge

The Vermont Bridge was built around 1870 in Dummerston, Vermont originally spanning the Stickney Brook. This bridge allowed Vermont route 30 to cross the Stickney Brook facilitating travel from Southern New England through to New York. The bridge served well until 1951, when Vermont slated the bridge for replacement. A concrete structure replaced it.

Upon the bridge being sited for replacement, Old Sturbridge Village approached the Vermont Highway Department regarding the procurement of the bridge for Old Sturbridge Village, a living museum that was opened 5 years earlier in June of 1946. The Vermont Highway Department subsequently sold the bridge to the village for the sum of one dollar. The bridge was then carefully disassembled, with each part mapped and numbered, and moved seventy-eight miles south to Sturbridge at a cost of over twenty-five thousand dollars. However, this is not the most dramatic period in the bridges history.

The most dramatic event occurred four years later, in August of 1955. Hurricane Diane unleashed some of the heaviest rains ever recorded in New England. As much as 19 inches of rain fell across Massachusetts, setting rivers on a rampage that left several New England towns looking like they had been devastated by war and more than 180 people dead. The damage totaled more than $800 million (approximately $5 billion in today's dollars). Old Sturbridge Village was not spared. Dams broke in Sturbridge, Southbridge, and Charlton and the Covered Bridge was washed off its foundation. The bridge was only saved from floating downstream by the efforts of the village staff.

Shortly following this near catastrophe, the bridge was relocated to its present location spanning the channel that connects the village millpond with the Quinebaug River.

Critique of Earlier Work

The two previous IQP reports that were written attempted to explain the technical significance of the Vermont Bridge at Old Sturbridge Village, these reports defined the engineering principles well, although neither report presented the material in a way that was easily conveyed or understandable to the general public.

The previous reports more than adequately defined the engineering principles that apply to the design of truss bridges, and the history of bridge design. Yet there was little attention focused specifically on the Vermont Bridge. I intend to incorporate the history of the Vermont Bridge, both before and after the bridge was acquired by the village. As well, as incorporating a more general explanation of the technical aspects of truss bridge design and bridge design history.

It is necessary to develop a clear and concise explanation of the technical aspects of the Vermont Bridge, while maintaining the information at a level that can be easily understandable to public. This being said the information needs to be presented without the unnecessary use of complicated terminology. Although the report written by Schreiner, DeBlois, and Cooper did a much better job on this than the previous report, it is still more complicated than it needs to be. As the main goal of this project is to develop new signage for the Vermont Bridge, I intend to develop a short, yet informative explanation of the technical aspects of the specific design of the Vermont Bridge as well as a separate but similar explanation of the bridge's history.

Beyond the new signage, it is also a goal of this project to develop a website for the Vermont Bridge, to replace the current page. I would like to see the covered bridge main page more adequately explain the history of the bridge. With links from this page, I would like to incorporate further information regarding the design and design history of bridges, as well as possibly a directory of other surviving covered bridges in New England.

As a frequent visitor to Old Sturbridge Village, it is important to me to maintain focus on the mission of the village. It is important that the information presented to the public at this living museum, be in a format that allows visitors to find meaning, pleasure, relevance, and inspiration. My intention is to view this as an opportunity to further advance the mission of the museum in a way that allows all visitors to fully appreciate the historical and technical significance of the Vermont Bridge. Neither of the previous, IQP groups had the consistent connection with the village, as I have had throughout my life. I believe that this will allow me a greater understanding of the needs of the village from a visitor's standpoint.

Terminology

In order to understand how bridges work, there are certain concepts that need to be understood. Perhaps the most important principle is that of force, force is the push or pull on an object by either gravity or an outside influence. This force is applied in several different ways. Some of these ways are compression, tension, and torsion. Compression is a force that acts to compress the object it is acting on, in an attempt to crush or shorten the object. Tension is a force that acts to expand, lengthen, or pull apart the object it is acting on, and torsion is a force that twists the object. When trying to open a bottle of soda or a jar, a torsion force is applied.

Figure 1: Tension and Compression Diagram

With all these forces acting on objects, failure can sometimes occurs. All objects have some resistance to failure. Buckling occurs when an object cannot handle the forces of compression, and snapping occurs force of tension overcomes an object's ability to handle tension. Another form of failure is bending. The resistance to bending is stiffness, and strength of an object is an objects resistance to breaking.

Bridge Information

As we, all know a bridge is a structure that allows people or vehicles to cross an obstacle such as a river or a highway. The definition of a bridge requires the structure to cover some distance between supports; this distance is the span of the bridge. The supports of the bridge are piers. To be a functional bridge, the structure must also have a deck, which is the horizontal platform that carries the roadway, railway or walkway.

There are three main types of bridges. These three types are the simple beam bridge, the arch bridge and the suspension bridge. The biggest difference between the four is the length of span that is possible. A beam bridge or a truss bridge can span up to 200 feet, an arch up to 1,000 feet and a suspension bridge is capable of spanning up to 7,000 feet. These bridges all work on a standard concept of transferring the weight and the load of the bridge to the piers, but each transfers the load in different way.

The beam bridge has the simplest design. It consists of a deck supported on either end by two piers. The weight and load of the bridge is transferred directly downwards, relying on the ability of the deck to bend slightly without failing. This bending compresses the upper part of the deck and pulls on the lower part. The bridge pushes down on the supports, transferring the load to the supports.

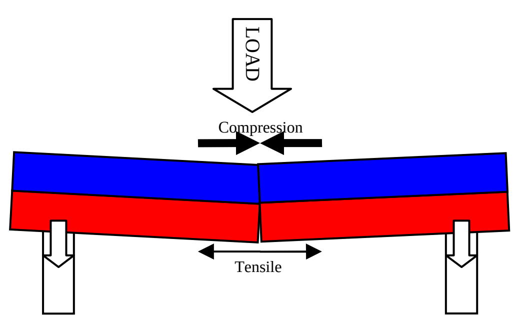

Figure 2: Simple Beam Bridge

A truss bridge is an enhanced version of a simple beam bridge. The truss is one of the most important engineering structures. The structure is constructed from several straight and slender members connected only at the joints. Much like the simple beam, the top members of the truss experience compressive forces and the bottom members experience tensile forces. The vertical inner member experiences compression in most cases, however there are members that do not experience any forces and exist only to reinforce the structure. The image below shows the forces, the red members experience tension, the blue compression and the black exists only to make the truss stable.

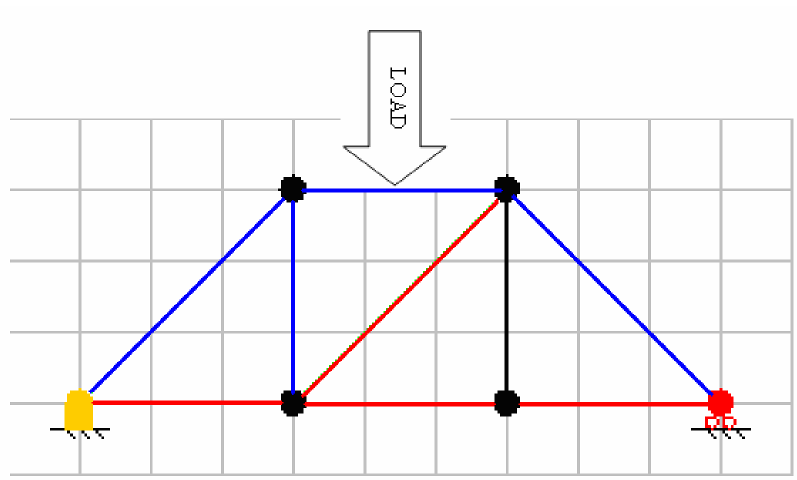

Figure 3: Truss Bridge

The arch type bridge are the second oldest bridge type behind the simple beam bridge. Arches use a curved structure that due to the shape has a high resistance to bending. Unlike beam and truss bridges, both ends of an arch allow no horizontal movement. When a load is placed on the bridge, compression forces occur through out the structure. The compressive forces push against the supports to transfer the force.

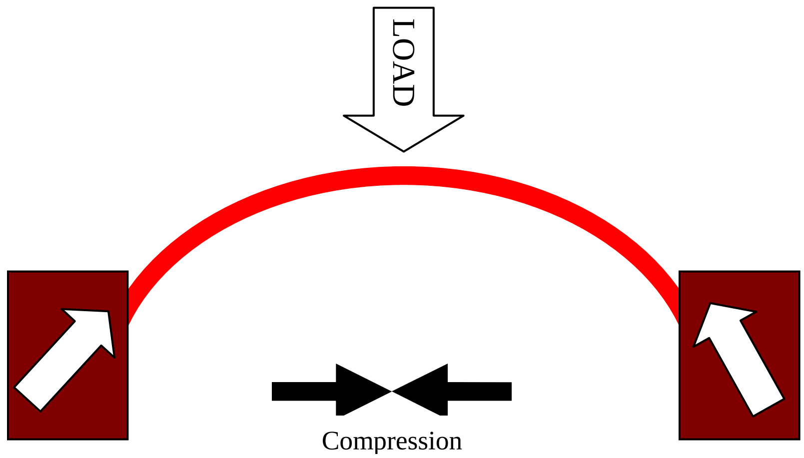

Figure 4: Arch Type Bridge

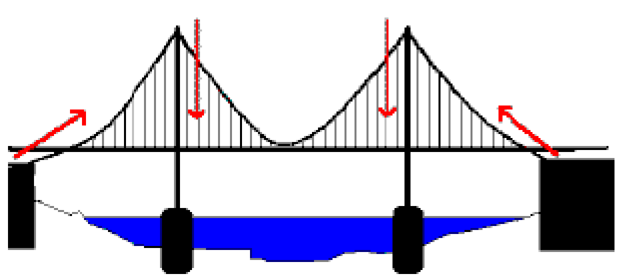

Figure 5: Suspension Type Bridge

The final and most complex type of bridge is the suspension type bridge. With the suspension bridge like the simple beam bridge the deck rests on piers, however unlike the simple beam bridge cables that extend through the pier on one end also support the deck and the pier on the other with each end fastened to anchorage on either end. Massive weights used to stabilize a suspension bridge are Anchorages. When a load is applied to a suspension bridge, the cables are placed into tension. This tension places a compressive load on the piers transferring the entire load to the ground below.

History of Truss Bridges

A tree that had been cut down and laid across a narrow brook was most likely the earliest bridge. These types of simple beam bridges are known as a stringer bridge. The stringer bridge functioned only as a narrow walkway, and did not allow animal or vehicular travel. The height of the trees in the area limited the span of this type of bridge. This type of bridge was modified to provide for a larger deck surface. The modified stringer bridge worked well as long as the span required was relatively sort. As a bridge of this type became longer, the center of the bridge was prone to sagging and slipping from its supports. Further modifications were done to counteract this issue, resulting in the pile and beam style, which was supported by added supports at the center.

At this time, there were two other options available, the floating span and pontoon bridge. Both of these two designs involved the bridge floating on the water. With the floating span bridge, the bridge floated directly on the water. The pontoon bridge floated on top of small rowboat type crafts. Both these bridges were prone to rot, caused by the exposure to water. The lack of longevity of these type bridges and the limitations to the length of the stringer type bridges lead to the development of the first truss type bridges.

Modifications to the stringer bridge resulted in the kingpost truss. Additional bracing to the underside of the stringer deck, and two triangle shaped braces were added. This resulted in the first true truss type bridge. This type of bridge was simple to construct and most carpenters could construct one, as it was similar to structures that were used in barn and house construction. This design worked well for short spans however, larger spans required further modification. The next modifications lead to replacing the pointed section of the truss with a horizontal member, this allowed the span to increase. The resulting truss is the queenpost truss.

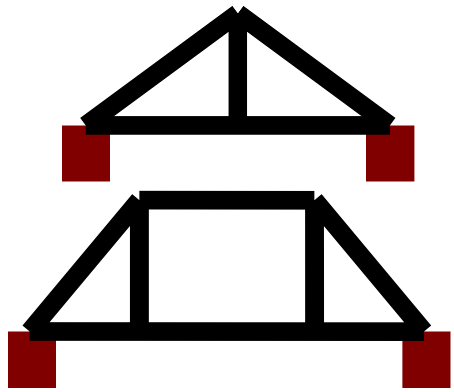

Figure 6: Kingpost and Queenpost Truss Bridges

Following the modification that resulted in the king and queen post style bridges, more modifications took place. Starting in 1804, the Burr arch bridge, which was a combination of multiple kingpost trusses with a reinforcing arch, was used for spans in excess of 250 feet with only support on the ends. In the following 50 years, several other types were developed. These included the Town Lattice in 1820, the Long truss in 1830 and the Howe truss in 1845. The Vermont Bridge is an example of the Town Lattice.

Ithiel Town and the Town Lattice

Ithiel Town developed The Town Lattice in 1820. Ithiel Town was born in Thompson, CT in 1784, as the son of a farmer. He was trained in architecture in Boston, and owned a successful architectural firm. In early 1820, Ithiel Town patterned the first version of the truss that bears his namesake. Although the original design was not fully successful, Town further refined his design leading to one of the most popular and successful bridge truss designs of its time. Town overlaid four triangle trusses, into a system that resembles a garden lattice, with this design; loads were more efficiently distributed across the full truss,

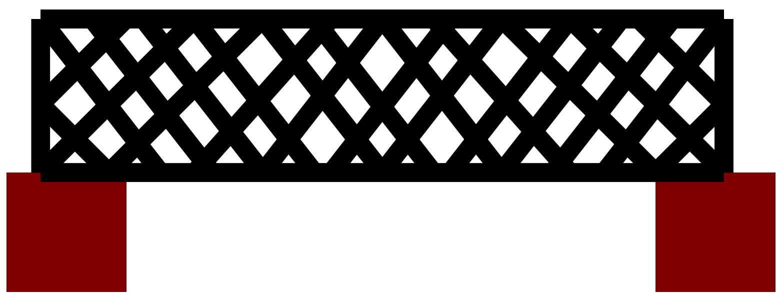

Figure 7: Town Lattice Truss Bridge

Town’s Lattice Truss Bridge was not only a sturdier bridge then earlier designs but it also eliminated the need for large wooden timbers like the ones where necessary for the kingpost and queenpost style bridges, the design instead made use of milled lumber that was more readily available. Town’s design also eliminated the need for mortise and tendon joints, a common problem area in earlier bridge designs. The elimination of these joints not only strengthened the bridge it also simplified construction. Anyone with only the barest knowledge of carpentry could easily oversee the construction.

Covering the Bridge

A common question about the Vermont Bridge is why the bridge is covered. There are several reasons for this addition to the design. More critically is to protect the bridges structure by reducing the amount of rain and snow that the bridge is exposed. This reduces the rot and breakage due to freezing. It also helps reduce shrinkage from the sun drying the timbers. The roof dramatically increased the lifespan of the bridge, often doubling the life span. Another reason to cover the bridge is due to the further stiffening of the structure. The addition of the roof reinforces the truss sides, as it does not allow the sides to sway inward. This would again increase the life of the bridge, as it reduces fatigue in the lower joints of the truss.

Detailed Critique of Earlier Work

During the course of the current Old Sturbridge Village- Worchester Polytechnic Institute partnership, two reports have been written, in an attempt to present information regarding the Vermont Bridge to the patrons of the museum. These reports by Courcey, Roy and Wixon and Schreiner, DeBlois and Cooper, have formed an adequate basis to that must be further developed. The intent of this report is to analyze each of these two reports to determine what was effectively presented and what needs further work.

We shall analyze the beginning matter of each report as well as each section. Special attention will be given to each of the diagrams, as the outcome of the final project will require effective use of visuals. We shall begin with the report from July 1, 2004 by Courcey, Roy and Wixon.

The purpose statement of this report was left extremely broad, and did not address the making the material compatible with the museum's objective. This is a continuing issue throughout, as the material in general is presented in a form that would be extremely hard to present to a non-technically oriented public. Undue attention was also paid to the software the team used, as it is not necessary to explain the mechanics of the tools used, it is sufficient to mention the use.

Within the technical aspects area of the report, more attention was paid to presenting the information in a public friendly format, these attempts last about three pages. The information on the different types of bridges would have been better presented had the descriptions of the structures been separate from the mechanics on the structures. Prior to describing the mechanics of each of the structures, it would have been better to present information regarding mechanics such as force, tension and compression. Another issue with this section of the report, is that each of the diagrams of the force reactions of each of the types of bridges on pages 14 and exists on PBS's Building Big Bridge Page, as this page is copyrighted to WGBH. The use of these diagrams could cause legal issues. Original drawings and photographs would better suit the museum on a professional level.

Within the section that describes mechanics, language is used that is well above that of the public. Terms such as abutment, normal forces and bending moments are used but not defined. A person who had no technical knowledge would not be able to comprehend the information that is presented. The pencil exercises portrayed further confuses the reader and adds no value to the report. A term that is used that the general public may not know should be defined prior to it use, or it may lead to confusion. In addition, diagrams should be easily understandable, and in only two dimensions when at all possible.

The section on tensile strength also swells well above the knowledge of the public, with extraneous information that does nothing to further the understanding of the mechanics. It was not necessary to discuss the specific regarding the strength or the composition of wood. This section had no information that was necessary or valuable.

The technical information presented in the section on truss system has some technical merit; however, it is presented in a way that is neither effective nor easily understood. The language again is well above the targeted user. Erroneous information was also prevalent (i.e. the species of wood used for each segment of the truss system).The next section on Truss construction techniques could have been better summarized in a couple of sentences, with in the truss system segment.

The section on the Town Lattice was well presented. It did however; reference the relation to the Kingpost design that had not been previously discussed. In the later part of the section, the information on green timber was redundant, as it had been mentioned in the previous section. Again, the section regressed into language that was too advanced. This section adequately covered some of the advantages of the Town truss over other truss designs however further work is required to highlight more of the advantages.

Possibly the one of the best-written section of the report was the explanation of the reasons to cover a bridge. This section was clear and concise with language, which was well within the realm of the target audience. The two remaining sections were equally well written. Both of these sections would have flowed better had they been presented earlier in the paper. The remaining sections are not pertinent to the current objective of this project, so will remain un-critiqued.

The second paper form December 11, 2005 by Schreiner, DeBlois and Cooper was much better written. The beginning matter was well organized, with a well-defined purpose statement and adequate literature review. The information was presented in more of a public friendly format, a trend that continues throughout the report.

The following introductory section on the types of bridges was well organized, and well presented. The diagrams were simple and easily understood. However, some of the language in the bridge type discussion is wordy, and words like tension were used prior to being defined. The placement of the diagrams also was not ideal, often on the page following the description of the bridge type. Due to the subject of this report it would have been to their advantage to discuss truss bridges in further detail, and possibly reduce the attention brought to the other bridge types especially those options which weren't currently available at the time of the Vermont Bridge's construction.

Within the section on Physical terminology, the diagrams were well used to define the concepts of tension and compression, these diagrams would have been better illustrated had a spring in steady state been shown prior. This area of the report gets a bit too technical in its attempt to define critical concepts. A much simpler definition could be formulated that would allow everyone, including small children to understand the concepts without confusion.

The next section on the Function and Physical characteristics of bridges become a much more technical discussion than necessary. The diagram for the forces in a truss bridge, arch bridge and suspension bridge are well defined, however the diagram for the beam bridge is hard to understand for non-technical people, which do not understand the transfer of forces.

The section on the Town Lattice was well presented. The advantages of the truss design were clearly outlined. The diagrams provided further enhanced the information provided. The following section on the reasons for coved bridges was not as well written as the remainder of the report. More information regarding the benefits to a covered bridge should have been provided as it was in the earlier report.

The History and Evolution of Bridges section were also well written as was the sections on truss systems. The following section of Truss bridges as a sign of Progress was slightly disconnected and should have been condensed and connected to the section on the history of bridges and the section on the Town Lattice respectfully.

The remaining section of Ithiel Town seemed very disconnected. All the information regarding both Town and his truss design should have been presented as a package. This is the major issue with this report.

The first report had little cohesiveness and extremely technical information was presented. The second report did much better; however, the information in certain sections was presented at a higher technical level than required. The history of the Vermont Bridge in general was ignored as a whole within the second report, this information is critical to the objective of this project. The second report also should have been more cohesive, sections regarding the same information were scattered throughout.

The current attempt at the project will seek to condense the information presented in the two earlier reports, into a public friendly and informative format. The major challenges will be to present the information without the unnecessary use of technical jargon, in a cohesive manner. The history of the Vermont Bridge will also play a leading part in the current project.

Reactions

Upon completion of the main body of this report, it was submitted to Dr. Jack Larkin, Museum Scholar and the Chief Historian of Old Sturbridge Village, his reaction was as follows:

“This IQP report is a very good piece of work. It is well written, and accomplishes the goals that we set out for the project.” …”has summarized the engineering analysis of early wooden bridges begun by the previous IQP projects, and has translated these concepts into clear, understandable language and diagrams that can be used as an excellent basis for developing exhibit signage. I am very pleased with this as the final product of the project”.

Future Work

This report resulted in a clear and concise basis for the signage that Old Sturbridge Village requires. From the information gather in this project, current images and historical photographs of the Vermont Bridge signs can be developed that enhance the experience and support the mission of Old Sturbridge Village. Beyond the signage, the information gathered should be used to better enhance the Old Sturbridge Village website.

Perhaps another use of the information contained in this report, would be a village walk type activity. This activity could be used to better educate the public in much of the same way as the Cooper or Blacksmith. It would give visitors a more meaningful understanding than is currently available to the museum visitors.

Conclusions

In conclusion, it is my hope that the information presented in this project enforces the continued effort of Old Sturbridge Village's mission. This project presented the material in a way that is easily conveyed and understandable to the public. This project resulted in a short, yet informative explanation of the technical aspects of the specific design of the Vermont Bridge as well as a separate but similar explanation of the bridge's history. I believe the experiences a when I was a child allowed me a greater understanding of the needs of the village from a visitor's standpoint. This relationship with the village accounted for the ability to develop this project in such a way as to be useful to Old Sturbridge Village. As I have always wanted to participate in one form or another with the continuation of the museum, this project was for me a great experience.

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