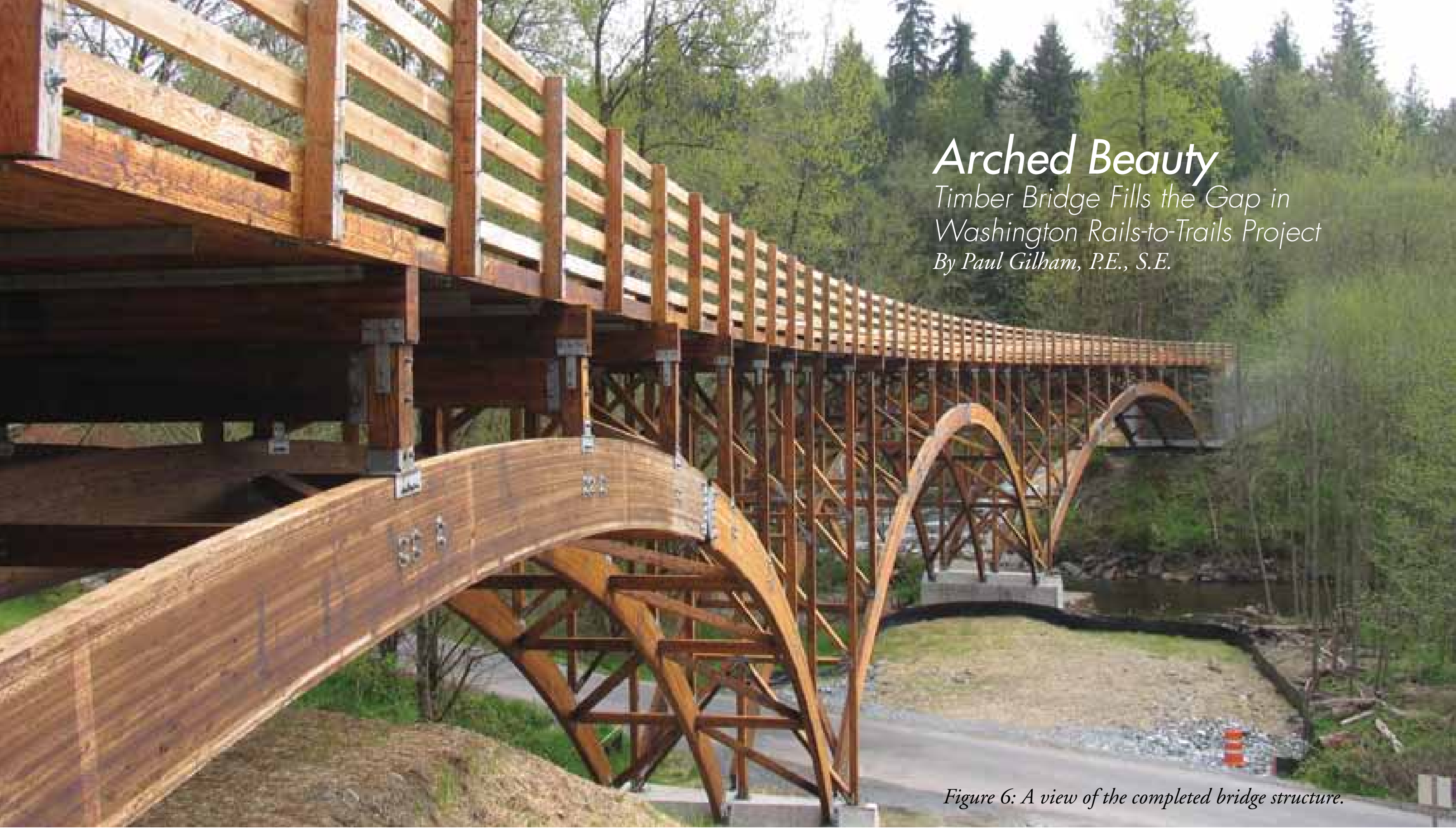

Arched Beauty

Timber Bridge Fills the Gap in Washington Rails-to-Trails Project

By Paul Gilham, P.E., S.E.

Figure 6: A view of the completed bridge structure.

After diligently pursuing the completion of the Foothills Trail near the town of Buckley, Washington for more than 20 years, the Foothills Rails-to-Trails Coalition has successfully overcome a large obstacle in its path.

The Lower Burnett Road/South Prairie Creek Bridge, located on the Foothills Trail, provides a link connecting a 15-mile section to the south with a 1.8-mile section to the north. When completed, the Foothills Trail will be more than 28 miles long and will connect to the Interurban Trail. The trail is built on the Burlington Northern Railway line, abandoned in 1982. The Foothills Rails-to-Trails Coalition has been working with Pierce County Parks since 1984 to develop this trail, and this bridge now provides a major link in the system.

The 400-foot long by 40-foot deep gap created by the removal of the original railroad trestle posed a major obstacle. The Coalition and Pierce County Parks Department turned to a design/build contract with Western Wood Structures, Inc., from Tualatin, Oregon, to purchase a bridge that fit the rural setting while remaining economically feasible. The end product aptly demonstrates the ability of glue-laminated timber construction to achieve complex geometry while maintaining high aesthetic value.

The bridge spans both Lower Burnett Road and South Prairie creek. The elevation of the rail bed is roughly 40-feet higher than the roadway and the 100-year flood elevation. The bridge is located on an S-shaped switchback where the rail line gains 200 feet over roughly 2 miles. The horizontal radius of the curve for this portion of the trail is just inches shy of 650 feet.

Bridge Layout

South Prairie Creek is approximately 51-feet wide at the bridge crossing. On the south side of the creek, the bank rises sharply to the rail bed, approximately 40 feet from the edge of the bank. On the north side of the creek, the terrain is relatively flat between the creek and the roadway. North of the roadway, the bank rises up steeply to meet the elevation of the rail bed. The specifications required a minimum 15-foot high clear opening for the bridge over the 24-foot roadway. There is a 4-foot elevation gain from the beginning of the bridge to the end, and a curvature of 34.5 degrees between abutments.

Contracting Methods

Pierce County employed a two-stage contracting method for the design and installation of the bridge. The first contract was a design/supply/install bid for the timber superstructure. The contract documents for the bridge superstructure contained the general layout for the bridge with the required clearances, elevations, curvature, and loading. It was required of the bridge supplier to provide a structural design that met these contract requirements. The under-deck arch scheme had previously been chosen by the county after preliminary consultations on feasibility several years earlier. This framing system was beneficial for several reasons:

1) The curved deck could be supported frequently by bents with the position of the floor beams varied to fit the curve.
2) The arch structure is more efficient than straight stringer spans as they transfer both vertical and lateral loads to the

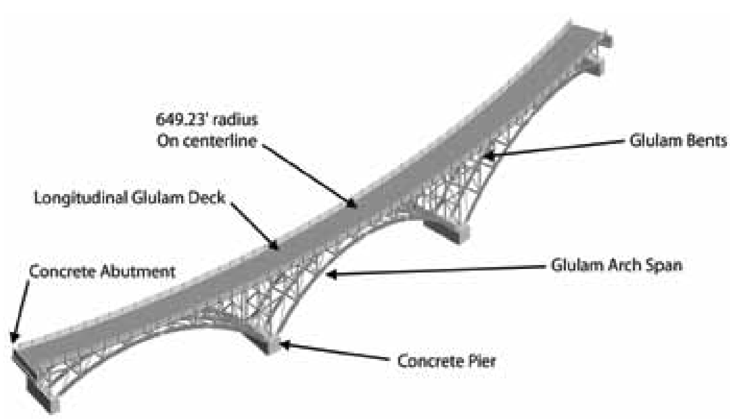

Figure 1: Rendering of Bridge.

foundations, eliminating the need for massive bents at the abutments.

3) The arch structure offers a more graceful aesthetic, giving the bridge a flow from one end to the other.

The second contract was to construct the trails leading up to the bridge, and the bridge substructure's concrete foundations. The design of the trail and substructure was completed by county engineers. The bridge design contractor provided the county with the foundation layout and reactions so the county could complete the foundation design.

Western Wood Structures, Inc. submitted the winning bid to completely design the bridge, supply all of the timber components, steel assemblies and connecting hardware, and provide labor and equipment to install the bridge superstructure. The contract drawings schematically showed longitudinal stringers with a transverse deck. Western Wood Structures' engineers opted for the longitudinal deck system for several reasons. In a bridge with transverse decking, the curvature must be formed by varying the deck overhang. In this project, the overhang would have been excessive, requiring a thicker deck to provide the required strength and limit deflections. Next, this type of framing system requires a far greater number of steel assemblies to connect the stringers to the bents. Each of these assemblies would have needed to be unique to provide the appropriate orientation of the stringers. Using a longitudinal deck system eliminated the stringers altogether and greatly simplified the framing. For example, the deck panels are connected to the bent caps with standard steel angles and bolts.

Bridge Design Criteria

The bridge is designed primarily for pedestrian and bicycle traffic. An 85 psf live load was used, based on the AASHTO Standard Specifications for Highway Bridges. In addition, the bridge was designed to carry an H15-44 (15-ton) vehicle. This vehicle governed the design of the longitudinal deck and the bent caps. This design is considered an infrequent loading condition, as only maintenance and emergency vehicles will be allowed to access the bike path. A 1.33 load duration factor was used for the load combinations that include vehicle loading.

The bridge is made up of three main-arch spans with two smaller approach spans. The arch spans are 127 feet, 128 feet 7¼ inches, and 118 feet 4¼ inches; the two approach spans are 8 feet each, for an overall length of 389 feet 11½ inches. The bridge width is 18 feet from inside face of curb to inside face of curb. The arches are made from Douglas Fir glue-laminated timber (glulam). Each arch span consists of three 3-hinged arches with a circular curvature. In plan view, the arches are laid out on the chords of the horizontal curve and are spaced at 8½ feet on center. The radii of curvature for the arches are 98.5, 78.5, and 118.5 feet for the south, center and north spans respectively. Separate radii were chosen to account for the difference in elevations from the end abutments to the center abutments, and to provide visually similar distance from the bridge deck to the arch. The use of arches as main carrying members greatly reduced the foundation requirements by minimizing the number of piers required to support the bridge. Chevron bracing was used between the arches to transfer lateral forces to the abutments.

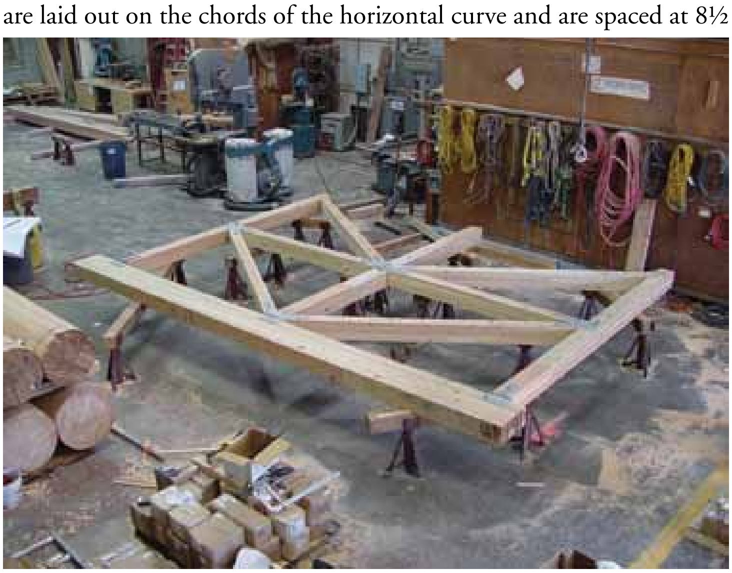
Figure 2: Pre-assembly of timber bents at fabrication.


Figure 3: Installation of arch chevron bracing.

Each arch has eight timber bents spaced evenly along the bridge centerline and placed at right angles to the arches. The bents were placed close enough (ranging from 13 feet to 14 feet 3 inches on center) to minimize twisting of the deck panels. The curvature of the bridge and the elevation gain complicated the bridge geometry, with the result being that each timber bent needed to be individually designed and detailed. Chevron bracing was also incorporated into the design of the bents to transfer the lateral forces from the deck to the arches.

Longitudinal glulam decking (6¾-inch) was installed on top of the timber bents. A longitudinal deck was chosen over a transverse deck because it could be manufactured with a horizontal curvature to match the roadway curve (*Figure 1*). The deck was designed with a two-span and three-span layup. This layup reduced the deck deflections to minimize cracking in the asphalt wearing surface.

Bridge Fabrication and Erection

A 3D solid model was created to completely detail the glulam members and steel connection assemblies for this bridge. This model was constructed using AutoCad's solid modeling capabilities.

Each steel assembly and timber member was extracted from the model and converted into a fabrication detail. Eighty-four pages of shop drawings were required to fully detail all of the arches, bents, deck panels, rails and steel assemblies.

During fabrication, each timber bent was fully assembled as it was fabricated. The steel connection assemblies were used to lay out the bolt holes. The bents were then disassembled and pressure treated.

The bottom ends of the vertical columns were left un-fabricated to allow adjustment to the overall bent height in the field. This is necessary to account for the tolerances allowed in the curvature of the arches. Since the preservative treatment penetrates nearly six inches on the end grain of these members, cutting off a few inches on the columns will not affect durability (*Figure 2*). Several of the glulam arches required moment splices because the total offset is limited to 6 feet, the diameter of the pressure treating retort.

After the glulam members were fabricated, the arches, bents and deck were pressure treated with Type A Pentachlorophenol. This preservative is a heavy oil preservative that slightly darkens the wood from its natural color. The glulam curbs, posts and rails were pressure treated with type C Pentachlorophenol. This treatment uses a light solvent carrier that leaves the wood clean. All of the glulam members were completely fabricated prior to preservative treatment, ensuring that the treatment envelope remained intact. The steel assemblies and connecting hardware were hot-dip galvanized. These measures will ensure that the bridge will have a minimum 75-year service life.

Bridge Installation

Installation of the bridge began in November of 2008. An extension of the fish window of South Prairie Creek was required to allow installation of the southernmost span. By agreement with Washington Department of Fish and Wildlife, this span was completed by November 15th. After that time, no equipment would be allowed to work over the creek. The erection crews assembled two arch halves on each side of the creek.

Pierce County had previously acquired a right-of-way through private property for materials and equipment to the south abutment. Two all-terrain hydraulic cranes were used to set the pairs of arches over the creek. The arches are pinned at the base and at the crown. The pin at the crown was installed by workmen in a JLG hydraulic man-lift. Workmen then installed temporary foot- and hand-holds on the top of the arches to allow access, in order to install connecting hardware for the arch bracing and bents. To achieve the proper deck elevations, the arch elevations were surveyed once each arch section was installed.

As previously mentioned, the arch curvature has a manufacturing tolerance. This tolerance affects the elevation of the arch at the bent location. This information was relayed back to the Western Wood Structures engineering department where the required height of each bent was calculated and given to the field crew, who then trimmed the columns to match the elevations on site.

The work continued until all of the bents and deck panels were completed. At this point the curb and rail systems were installed to finish the structure. An asphalt wearing surface will be installed on a separate contract as soon as weather permits.

Conclusions

The design and construction of a glulam timber bridge provided for a stunning structure to complete this link in the Foothills Trail. The complex geometry of the bridge required the use of 3D modeling to fully fabricate all of the glulam members before they were pressure-treated. The use of timber as a bridge material provides a structure that truly complements the natural beauty of the site.▪

Figure 4: Work continues on center arch span.

Figure 5: Bents on the center arch span are added and the northern arch span is set.

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All photos courtesy of Western Wood Structures, Inc.