

THE ROGER BACON BRIDGE

Nappan, Nova Scotia



Project summary

The Roger Bacon bridge, in Nappan, Nova Scotia, opened in December 2019. The new bridge, named after a former local MLA and provincial premier, reopened after two years of closure. The former Nappan bridge had succumbed to the elements and had to be closed to traffic in 2017. It has since been replaced with the longest clear span, three-lane design timber bridge in Canada. The 40-meter span bridge provides a direct link between the towns of Amherst and Springhill on Nova Scotia provincial highway 2.

The new bridge uses pressure treated glue laminated timber (glulam) arch construction that is significantly lighter in weight and more resistant to the local environmental conditions than competing structural materials. With an estimated service life of 75 years, the total cost of the bridge replacement project was \$3 million.

1. View looking north. The Roger Bacon Bridge is the only 40-meter clear arch center span with two 12.5-meter jump spans, for a total length of 65-meter, three-lane highway rated (62.5 tonne) engineered glulam bridge in Canada.
2. Two arch pairs per side allows for the removal of one of the four arches or tension chords for maintenance without closing the bridge to traffic. Roofing material added to arch tops prevents water damage.



Design and Construction

The former Nappan bridge and its abutments were removed in the summer of 2018 to get the project ready for a tender call. Prior to letting the tender, the province had all the timber piles inspected and they were found to be sound and still viable for the next hundred years. Wood, when properly preserved and utilized, can last hundreds of years. Venice, for example, is built on 700-year old timber piles. Without oxygen, wood does not deteriorate.

The province tendered the bridge in late 2018, after which the tender was awarded to Wood Research and Development Canada (WRD), along with its sister company, Timber Restoration Services, both of Moncton, New Brunswick. The treated glulam arch design won over competing steel options, the cheapest of which was still 33% more expensive than the winning bid. The new glulam bridge, in addition to being much less expensive, is also much lighter than other options. This bridge is one third the weight of the old steel bridge, and one-eighth the weight of a similar concrete bridge. The existing piles were reused with only minor repairs, and with the lighter load, are in service at a fraction of their load carrying capacity.

The bridge design had to accommodate elevation restrictions from above and below. The lowest point on the bridge was required to be elevated above the hundred-year flood line but the road elevations could not be raised in order to maintain safe sight lines through the bridge for the travelling public. To meet the load requirements of the bridge within a compressed envelope, glulam incorporating high-strength fiber reinforcements along with advanced assembly techniques had to be employed.

3. The new copper naphthenate-treated pile cap system transfers the forces from the four corners under the arch terminus of the superstructure to the existing 56 timber pile clusters on both sides of the river. Five rows of transverse "C" caps were aligned directly on top of the five rows of the existing pile tops. The "B" caps were oriented longitudinally, directly below the arch-tension chord pin connections. WRD's patented shear panels were incorporated into the larger top "A" caps to minimize the need for larger glulam timbers. Extra strength and shear capacity were built into the "A" caps using the least amount of cap material to satisfy the bridge elevation restrictions.

4. WRD specified that all engineered glulam to be treated with an oil-based preservative such as copper naphthenate or pentachlorophenol. The bridge was preassembled indoors for quality control. Once disassembled and the elements sent for preservative treatment, no further drilling of holes or cutting was allowed on the job site to preserve the integrity of the treatment layer.

5. Detail of the underside of the bridge showing the lower galvanized steel supports sandwiched between the two redundant bottom tension chords.



3

Notes: 1) Lift connectors under the girders for adjusting the height of the jump span to match the finish height of the centre span. 2) The thrust rods below on the "B" level caps for the adjustment of the centre span to match the preassembled bridge arches for a perfect lift into place with .05mm accuracy.

4



5

The use of high strength reinforced fiber in the form of glulam laminates and shear panels allowed Wood Research and Development Canada to be able to reduce member depth and overall volume of treated engineered glulam to stay within the elevation restrictions of the client brief. "Having designed the longest clear span three lane engineered glulam bridge in Canada for 62.5 tonne carrying capacity, it pleases me that it is also longer lasting, more carbon friendly, and lower in cost than a steel or concrete bridge" stated Dr. Dan Tingley, Director of Wood Research and Development Canada.

The glulam components of the 65 meter bridge were drilled, cut, and pre-assembled in the factory before being disassembled for ease of transportation and construction on site. Once disassembled, the bridge elements were pressure treated using an oil-based preservative for decay prevention and to ensure a 75 year plus service life.



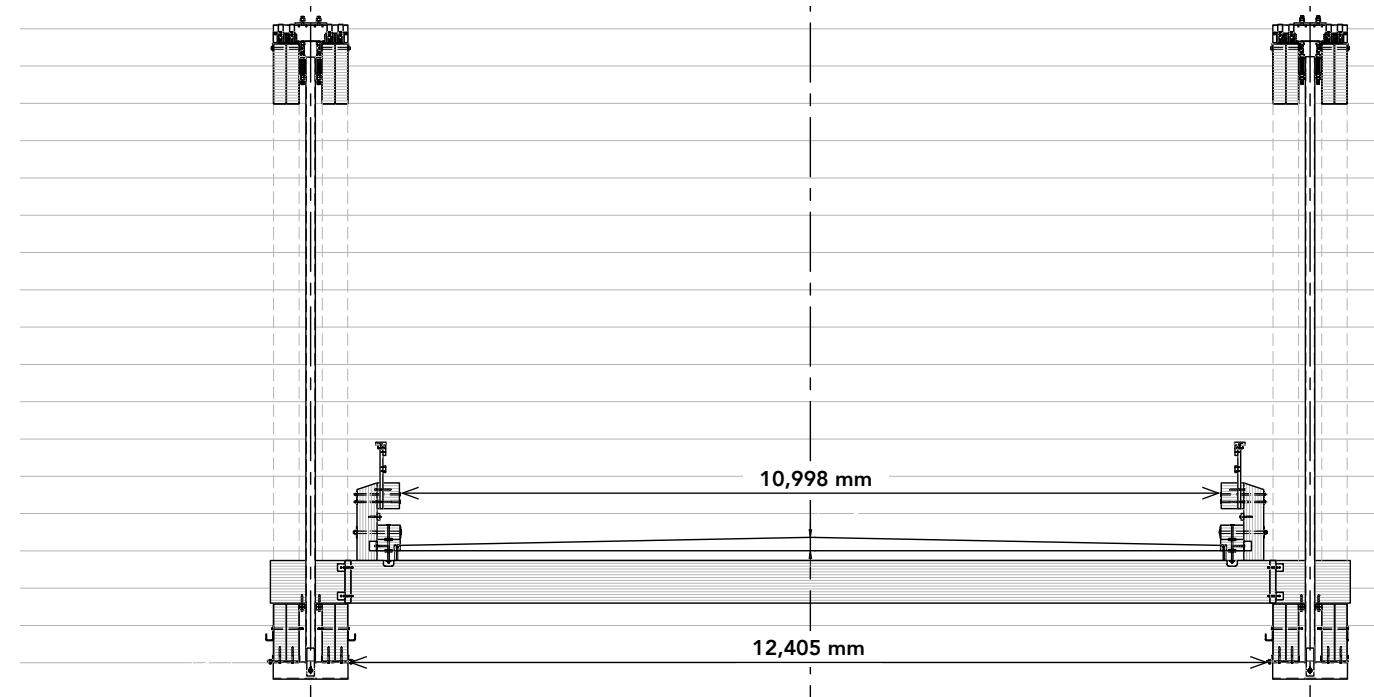
6. The partially assembled components of one of the arch pairs in the factory. The components were pre-drilled for connectors and then pressure treated with an oil-based copper naphthenate preservative which imparts a dark green colour.

7. The new engineered glulam bridge deck on the 14m-long jump spans with kerbs in place. Note the second 14m jump span on the other side of river.

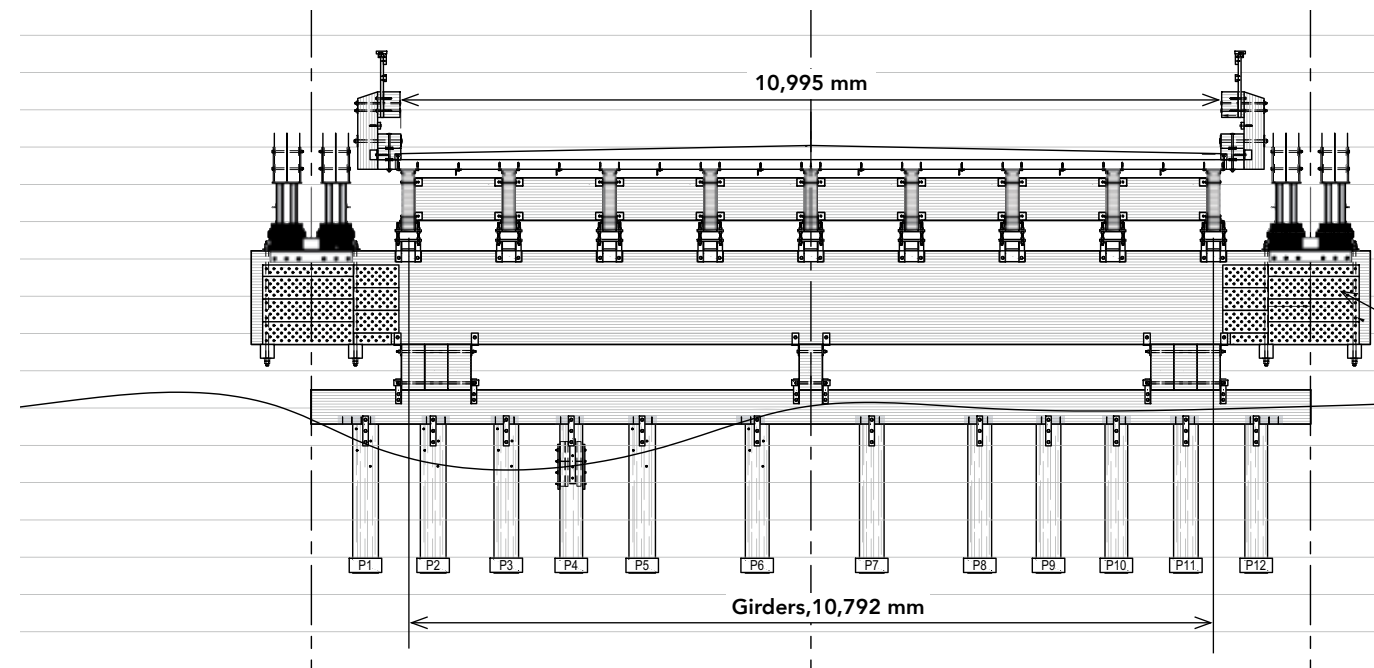
8. The south end 14m jump span. Note the minimal vegetative disturbance and clean job site. The new copper naphthenate-treated substructure was easily assembled on top of existing creosoted timber piles. Only a dozen or so of the pile tops needed repair and restorative work was complete before the arrival of the new engineered glulam superstructure. The new treated engineered glulam bridge only needed 25-30% of the existing 152 piles capacity to meet the design criteria for the three lane, 62.5 tonne 65m crossing.

9. Assembled floor decking sections, resting on galvanized deck supports and cross-beam assemblies, were lifted into place in less than a day.

10. A 500-tonne capacity lifting crane was used to place the 38-tonne arch pairs on the jump spans. The substructure of the jump spans was designed to accommodate the crane to bring it close to the lift. Movement beneath the jumps spans was monitored with sensors before, during and after the lifts to confirm that the capacity of the spans was not exceeded. Note the minimal disturbance to vegetation and the clean job site.



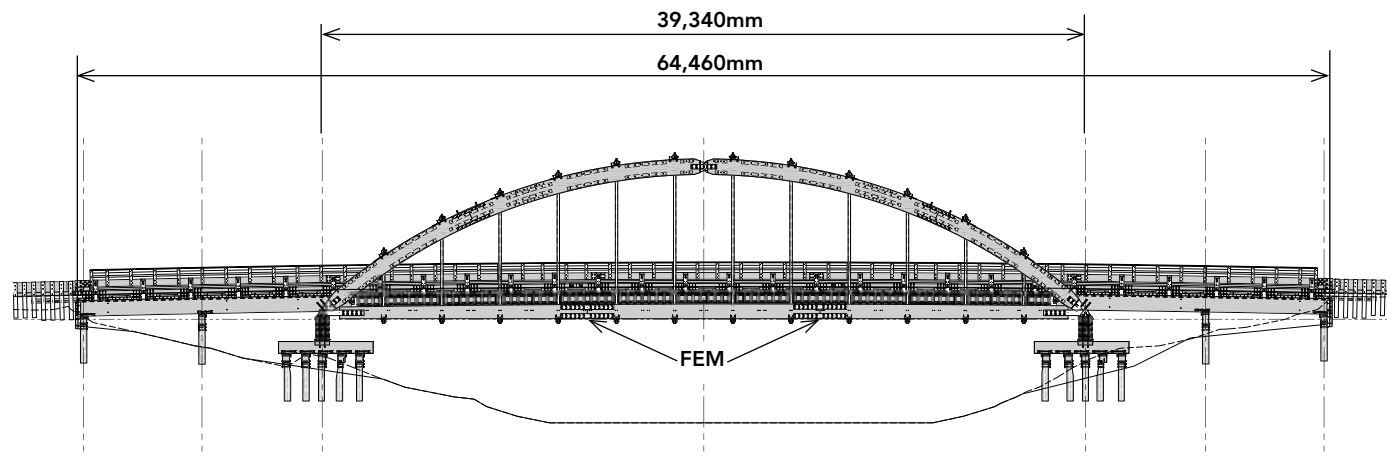
Centre span section



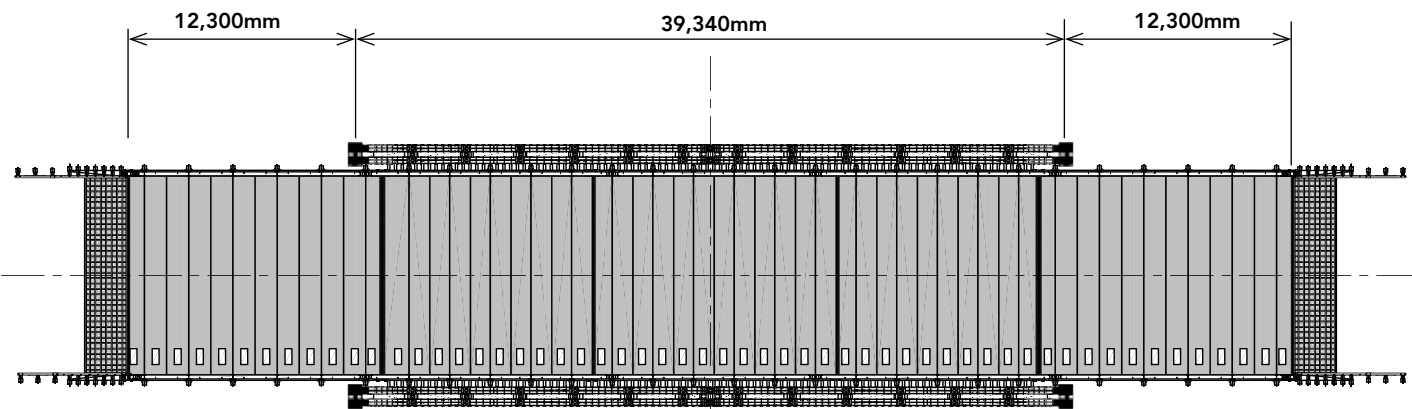
Shear panel

Jump span section

The design for the structure needed to allow for clearance of the 100-year flood line, while at the same time keep the elevation of the top of the deck low enough for sight clearances. To achieve this, shear panels were installed in strategic locations to gain the required capacity in shallower beams.



Elevation: Fixed End Moment (FEM) connections were used to allow these long, continuous, support elements to be pressure treated and transported.



Plan view



11



12

Offsite assembly of the bridge components at a nearby location and onsite installation took eight weeks. For Timber Restoration Services, the Roger Bacon bridge is the first timber bridge the company has built on an existing substructure in Nova Scotia.

Nova Scotia, as well as other regions around the world, are finding that timber bridge construction, compared to steel and concrete bridge construction, can provide predictable service life in exposed marine environments that typically have high corrosive and high relative humidity conditions.

The new Roger Bacon bridge meets all the requirements of the Canadian Highway Bridge Design Code and is North America's only timber 40 meter, single arch, three-lane highway bridge, rated for 62.5 tonnes. It also incorporates wooden guardrails engineered to the highest highway standards. The construction cost was 33% less than steel and 65% less than concrete alternatives.

11. The deck consists of 55 epoxied and screwed deck and transverse beam assemblies which form a solid continuous surface. The deck assembly was designed for easy repair in the future as individual panel assemblies can be easily cut and removed for quick and low-cost restoration work. The width of the finished bridge is 11 meters between guardrails which will allow three lanes of traffic. The road will remain as a two lane with an extra wide lane available for bicycle and pedestrian traffic.

12. View of the finished timber guardrails which meet the highest TL-4 standards for highways in Canada. To maintain minimal human contact with preservative treatment, Alaskan Yellow Cedar was used for the upper rail portion of the guardrails. This species has an extended life expectancy with its natural preservative characteristics so that the railings have the capacity to last 50 years.

Materials

Wood is an organic material, which means that it is biodegradable, however, it will remain sound and not deteriorate if protected from the elements. Timber bridge designs that prevent moisture and insects from penetrating beyond the treated wood's chemically protective outer layer can last 75 years, or beyond. Modern timber bridges may even employ composite materials in the form of glulam or fiber reinforcement to add strength, reduce beam depth, or increase span length. In recent years, however, it is wood's environmentally friendly and sustainable properties that are bringing it back into the spotlight.

Wood is the only natural, renewable, and sustainable structural material, and is the only one that can assist us in our fight against climate change. The International Panel on Climate Change, or IPCC, is a group of the world's leading experts on climate change. They agree that over the last century, the burning of fossil fuels and resulting CO₂ emissions have been the major contributor to the warming of the planet and resulting change in climate. While steel and concrete production emit significant amounts of carbon, the production of wood products emits much less. Growing trees also take carbon out of the air and store it in their own growth. Wood products which are harvested sustainably and used to build bridge structures sequester that carbon for the life of the bridge, resulting a net benefit to the environment. The wood used to build the Roger Bacon bridge sequesters the equivalent of 350 Tonnes of CO₂.

Quick Facts

- 65 meters long including a 40 meter arch center span
- Three lanes wide; highway rated at 62.5 tonnes
- 12 meters wide inside the TL4 rated timber guardrails
- Coastal Douglas fir incised and treated with oil-based copper naphthenate preservative
- All steel connectors and plates double coated galvanized beyond industry standards
- All large tension elements reinforced with high strength reinforced polymer fibers to add strength and reduce glulam beam depth and volume
- Service life 75 to 100 years with minimal maintenance
- Built for a 100-year flood event

Design Team

Client Nova Scotia Department of Transportation and Infrastructure Renewal
Engineering Wood Research and Development Canada
Contractor Timber Restoration Services
Photos Timber Restoration Services

13. Note the assembled upright supports connection details on the top of the arches.





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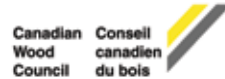


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