



Mistissini Wooden Bridge

Cree Nation of Mistissini

2017 TAC Environmental Achievement Award





One of Canada's longest wooden bridges

Project Overview

The Cree Nation of Mistissini wanted a new bridge to help them cross the Uupaachikus Pass and reach the land west of the village. Two objectives lay behind the construction of such a structure: access to a larger territory in response to the Cree Community's population growth, and access to a large gravel pit in order to meet the increasing demand for granular materials used in the community's construction projects. The project also included the creation of an access road to the gravel pit and extension of Main Street to the new bridge.

The structure had to satisfy a number of the community's needs and features, while supporting the passage of heavy vehicles. It needed to offer two traffic lanes, a sidewalk, and a safety fence to prevent falls. It also had to accommodate the passage of seaplanes under the structure, illuminate river piers for boating safety, and facilitate bridge maintenance by local labour.

In 2011, with hydraulic, geotechnical, and environmental studies completed, the Cree Community invited engineering firms to propose a design for the new bridge. Familiar with the initial design, which called for a steel and concrete bridge, the Stantec team demonstrated that a wooden bridge

could also meet—indeed exceed—the client's technical, ecological, aesthetic, and budgetary requirements.

Thanks to the community's openness, Stantec's team designed a new, 160-metre-long glue-laminated (glulam) wood beam semi-continuous arched structure. The structure comprised four continuous wooden spans combining straight girders and arches in wood. The latter were added inside each span in order to minimize the effects of the interior spans and lend an important architectural aspect to the design.

Inaugurated in November 2014, this is one of Canada's longest wooden bridges.



1,200m³

Glulam wood

Rethinking Wood as a Material of Choice

The Mistissini wooden bridge design is in itself a veritable innovation, thanks to its unique architecture and unusual use of wood as the dominant building material.

Above all, it was necessary to create a structural system capable of supporting road loads on spans that were nearly 43 metres long, whereas the longest item manufactured by glulam plants was merely 24.4 metres. To accommodate this assembly challenge specifically related to wooden constructions, a staggered joint method was used. The shear interface between arch element and straight beam are distributed through special plates fixed by annular nails. These connectors create an air gap and produce a better uniform stress distribution on the wood to increase the durability of the bridge.

Given the structure's complexity and innovative aspects, we involved the timber frame manufacturer and their manufacturing plant in Chibougamau early on in the project. That way, the manufacturer was part of the team and was present during design meetings. This approach enabled us to design according to production limitations. Technical solutions were thereby adjusted to the plant's manufacturing tools so as to best optimize bridge sections.

Furthermore, the glulam properties made it possible to eliminate expansion joints over the 160-metre bridge, giving the structure greater durability. Since temperature affects wood less so than steel or concrete (thermal expansion coefficient of 5.0×10^{-6} for wood), our designers opted for fixed supports on all sections in order to eliminate the need for expansion joints. This proved to be a **major asset for structural sustainability**, while usually a weakness in steel or concrete bridges when water damages the portions located beneath the latter types' joints (girders and abutments).

Another major innovation with this project was its deck waterproofing system. A membrane adhered to the wood decking was not considered to be a sufficient option for ensuring the deck's water-tightness, as the various wooden deck planks are installed with spaces between sections, allowing the wood to expand and contract in line with humidity changes; in which case, the membrane could tear over the holes. We therefore chose to add a marine plywood layer over the entire deck surface, thereby allowing for contraction and expansion of the wood without tearing the membrane, and thus protecting the deck planks during removal of the asphalt surface.

Lastly, wooden structures are characterized by their lightness in contrast with steel or concrete. A wooden deck is approximately one third the weight of a similar steel or concrete deck. During earthquakes, a lighter deck helps reduce load strain transmitted to the foundations, so that these can be reduced.

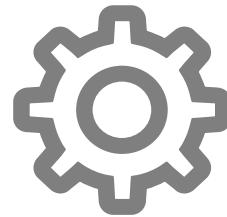
This project contained **numerous complex elements**, particularly regarding site accessibility difficulties and nordic environment constraints.

Firstly, the Village of Mistissini's remote location, 90 km northeast of Chibougamau in Northern Quebec, is accessible only via Route 167 North, making it hazardous to transport materials to the site. Moreover, with no easily drivable road to reach the Uupaachikus Pass's west side, it is difficult for concrete mixer trucks to get to the site. A forest road, drivable only in winter, allowed for access to some excavation equipment ahead of time. Even helicopter transportation came into play for concreting of the western side's abutment.

Furthermore, the bridge shape and soffit height needed to accommodate seaplanes passing under the bridge, since takeoff and landing by these planes in that region must happen either from the north or south sides of the channel, depending on weather conditions.

Wooden bridge construction using glulam for load-bearing elements is rare in North America. In fact, codes and standards require the use of rot-resistant materials or, where permitted, require treatment using a wood preservative.

Although Quebec glulam is sourced primarily from spruce—a very resistant tree species from a mechanical standpoint—it is practically impossible to treat using common industry preservatives. As such, we designed a deck offering primary protection against all types of weather, while joints between structural elements (beams and columns) were designed to dry quickly after exposure to rainwater. As well, a sealing product was used for the wood's exterior surfaces in order to **ensure structural sustainability** and enhance its architectural appearance.



4,000

Metal plates

152,000

Annular nails



The project promoted participation by the local workforce while supporting the region's economic development and environment

A Truly Sustainable Project

The Mistissini wooden bridge project integrates the **three components of a successful sustainable development approach**, in a harmonious and balanced manner.

From a social perspective, the creation of this new link has made it possible for the coastal population on the eastern side to access the western shore, thus bringing the community together. The project was warmly welcomed by the entire population, as the wooden bridge solution would ensure participation in the project by the local community first and foremost, while giving them the chance to carry out the bridge maintenance themselves, without the need to call in outside expertise. This approach promoted participation by the Aboriginal workforce along with a transfer of knowledge and skills.

The structure's aesthetic and innovative aspect was also a factor in popular acceptance and appropriation of the project, since the bridge integrated perfectly into the community's environment, **showcasing the region's natural resources**. The bridge quickly became a source of pride for the Cree Nation of Mistissini.

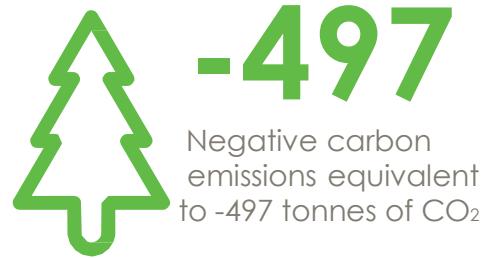
The choice of wood for the construction material also promoted the region's economic development.

Indeed, the price of raw materials in Mistissini is around 25% higher for concrete and steel, compared with larger urban areas. What's more, the glulam supplier's plant is located less than 90 km from the construction site, and they supply black spruce sourced from the region. In addition, the new link would make it possible to take advantage of the gravel pit, as per our client's wish, and support the region's medium - and long-term economic growth.



-90 km

From the construction site



We carried out a **carbon footprint analysis** just as we compared construction costs of various solutions, i.e., wood versus steel/concrete. Our analysis was based on the foundations (piers and abutments) as well as the deck.

In the end, the wooden bridge solution yielded negative carbon emissions equivalent to -497 tonnes of CO₂, compared to a steel/concrete bridge with CO₂ emissions equivalent to 969 tonnes. In total, the difference between the two solutions was 1,472 tonnes of CO₂, equal to the amount of CO₂ emitted in the combustion of 640,000 litres of gasoline. The wood manufacturing process absorbs rather than emits CO₂. Wood can be considered a carbon sink only if it comes from a sustainably renewed forest and the structure's life expectancy is sufficiently high (generally 100 years). These conditions were met on this project.

Moreover, the procurement of locally sourced wood, from a supplier located near the construction site, had a **positive effect** on the project's carbon footprint by limiting greenhouse gas emissions associated with materials production and transportation.

The project was also subject to an evaluation process with the Evaluating Committee (EVCOM) of the Quebec Ministry of Sustainable Development, Environment and Fight Against Climate Change (MDDELCC), in connection with obtaining environmental permits. Our team helped the Cree Community carry out their presentation and answer the EVCOM's technical questions related to these permits.

CO₂ equivalent emissions for wood bridge

Materials	Volume (m ³)	Unit emissions (kg/m ³)	Total emissions (t)
Wood deck	1282.8	-765	-981
Steel	4.6	8 968	41
Galvanized steel	0.6	13 678	8
Foundations reinforcing steel	12.4	4 697	58
Foundations concrete	1197.0	301	360
Bitumen	112.2	145	16
Total			-497

"We wish to highlight Stantec's team implication which was a determining factor in the execution of this very complex and environmental-friendly project. Great emphasis was placed by the technical design team on the structural integrity and aesthetic characteristics of our new and sustainable bridge."

Emmett Macleod, Director of Municipal Services, Cree Nation of Mistissini

Meeting Community's Needs

Stantec first presented two solutions to the client, namely, a bridge with a mixed steel/concrete deck, and a wooden bridge, with accompanying cost estimate comparison and architectural views.

This allowed the client to more clearly visualize the structure once completed. The wooden bridge solution, which proved to be the most interesting choice and the **most advantageous one economically, ecologically, and aesthetically**, was chosen by the client. Having collaborated with the Cree Community of Mistissini for a number of years, Stantec had already established a climate of confidence with this client, who appreciated our commitment to quality and respect for budgets and schedules. Thanks to that relationship of trust, the client supported our design team's vision and demonstrated considerable openness with regard to the proposed solution's originality.

In the end, the project was a great success for the community, fulfilling all of their needs in terms of required features, while contributing to the region's socio-economic development and pride on the part of the entire population. In 2016, the project has been honoured with a Canadian Consulting Engineering Award (transportation category) and also received the Engineering A Better Canada award, highlighting how engineering enhances the social, economic or cultural quality of life of Canadians. In 2015, the project received awards of excellence from the Quebec Association of Consulting Engineering Companies (AFG Quebec) and from the Quebec

Transportation Association (AQTr), and has been recognized in numerous presentations and technical conferences in the province, across the country, and internationally. The project was also ranked 6th among the 10 most important bridge projects in North America by Roads & Bridges magazine.

The project is truly rooted in this community's environment and culture, which values the richness and diversity of the region's natural resources. With this project, our team showed that it is possible to design structures that are at once safe, aesthetic, ecological, and sustainable. The Stantec team hopes that the design of this wooden structure will serve as a vehicle for inspiring innovation while helping to showcase Canada's transportation industry.



2016 Canadian Consulting Engineering Award – Transportation

2016 Canadian Consulting Engineering Award – Engineering A Better Canada



2015 Quebec Consulting Engineering Awards

AQTr 2015 Infrastructure Awards

Ranked 6th most important bridge in North America

Appendix

Mistissini Wooden Bridge

Photos









