Schwerlastbrücke (68 m Spannweite) im Norden von Canada

Heavy-duty bridge with a 68 m span in northern Canada

Pont pour trafic lourd, d‘une portée de 68 m, construit dans le nord du Canada

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1. Introduction

1.1. Nordic

Nordic is a company that focuses on four main points. First, the company is a sawmill (Chantiers Chibougamou) which includes the harvesting of trees. Secondly, it is an engineered wood product manufacturer. These products include dimension lumber, glulam, i-joists, and cross-laminated timber. Thirdly, Nordic is an engineered wood product distributor (Nordic Engineered Wood), with sales offices in Montreal (Quebec, Canada), Toronto (Ontario, Canada) and Albany (New York, USA). The last point is that Nordic also designs, fabricates, and erects wood structures.

The sawmill and factory are located in Chibougamau, QC, The project management and design office is located in the city of Montreal, which is about an 8hr drive south of the factory.

Image 1: Nordic company overview

1.2. Resource and Products

Nordic controls and manages approximately 2 million acres (approx. 8000km^2) of forest in the area around Chibougamau. The trees, the main resource for Nordics products, come from the nearby boreal forest that consists of 90% black spruce, at 5% jack pine and 5% balsam fir. Black spruce (picea mariana) has the following characteristics:

- trees are average from 70 to 120 years old (approximate mean of 80 years)
- mean diameter of 4.2 inches (107 mm) based on mean volume at sawing
- density of the trees provides lumber equivalent to 1950f MSR grade

Since the sawn lams are only 22mm x 44mm in section, Nordic uses a unique process in manufacturing glulam in that it divides the process into two main steps. The first step creates a glulam by laminating the above mentioned lams. The second step creates the final section by laminating the multiple glulam elements (created during the first step) into one large section. The result is a highly dense section that is more homogenous than typical glulam on the market. It can be manufactured up to 327mm x 2400mm x 24m in size. Nordic cross-laminated timber, which undergoes a more typical manufacturing process, has a maximum size of 381mm x 2.44m x 19.5m.

Image 2: Nordic glulam and cross-laminated timber

The flow chart below shows how the Nordic transformation of wood process.

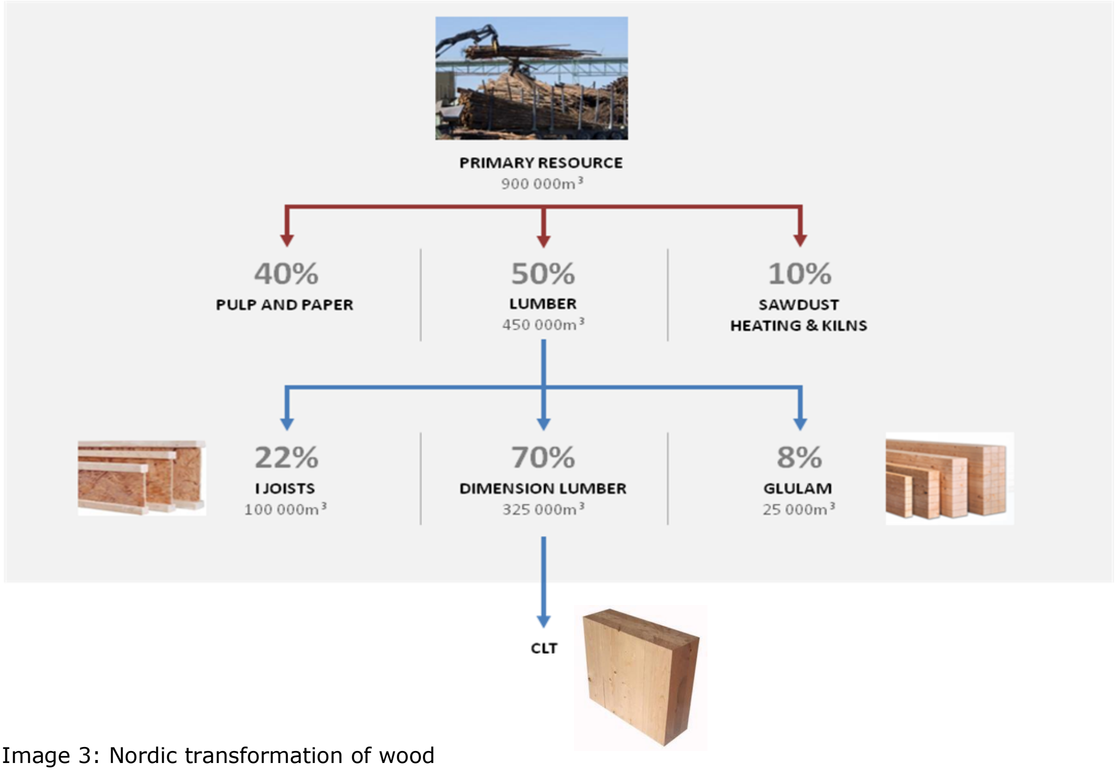


Image 3: Nordic transformation of wood

1.3. Process

Focusing on the structures department of the company, each project follows a specific process that is described in the image below. The main reference for each project is the 3d model. Whether engineering takes place internally or with external consultants, the project sequence is the same. Once a 3d model has been finalized, all the material lists can be exported, CNC data and shop drawings allow for the fabrication process to take place. As the project parts are being manufactured erection plans are being finalized. Nordic has an internal system that allows each part to be linked with scheduling data. This way it is always known when a specific part (glulam, cross-laminated timber, steel, or hardware) needs to be ordered, manufactured, shipped, and installed.

Since Nordic manages each project from forest to product to structure, it has created a process with multiple advantages. It is much easier to guarantee a product or project price, since it is not as dependent on resource price fluctuations. It is also much better for quality control, since there is limited or no reproduction of information.

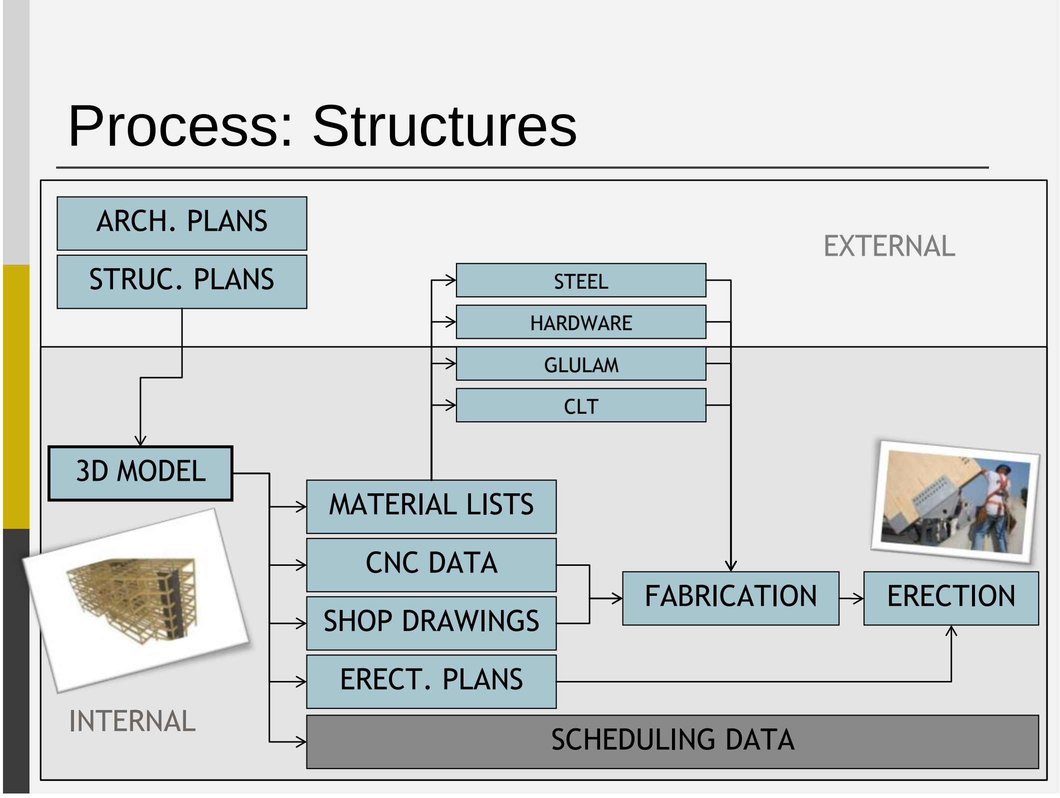


Image 4: Nordic project process

1.4. Projects

Nordic deals with a variety of projects. This includes industrial, commercial, sports complexes, residential, multi-residential, institutional, and bridges. The following images give an overview such projects.

Image 5: Glulam, post and beam, paper factory in Lachute, QC

Image 6: Airplane maintenance hangar and office in Dorval, QC

Image 7: Recycling centre in Roberval, QC

Image 8: Multi-storey office building in Quebec City, QC

Image 9: Soccer Stadium in Quebec City, QC

Image 10: Four-storey CLT condos in Chibougamau, QC

2. Bridges

Over the years there has been an ever-increasing demand for bridges, especially as applications for the road network of the tree-harvesting industry. Glulam bridges are ideal for this application because it has been proven multiple times that they are less expensive. Since a local resource is used and prefabrication is applied, bridges can be designed, manufactured, and erected in a matter of weeks.

The following images give an overview of the type of bridges that are being Nordic is building in Quebec’s forests.

Image 11: Témiscamie bridge (41,9m length, 34,9m free span, 175 tonnes capacity)

Image 12: Petite Témiscamie bridge (4,6m wide, 21,4m free-span, 175 tonnes capacity)

Image 13: Montmorency bridge (38,4m length, 32,5m free-span, 175 tonnes capacity)

Image 14: Albanel bridge (7,3m wide, 11,6m free-span, 175 tonnes capacity)

Image 15: Barette-Chapais bridge (4,6 m wide, 17m free-span, 175 tonnes capacity)

3. Maicasagi Bridge

Image 16: Maicasagi bridge

3.1. Introduction

The client, Chantier Chibougamau forestry, needed a bridge to give access to a forest near the Maicasagi river in northern Quebec. Not only was the span of 67.5m a challenge, but so was the tight project schedule as well as the high traffic load of 1800kN. There was only a certain time-frame in which the structure could be built. The site was on First Nations territory that required any obstacles in the river to be removed by a specific date in spring when fish populated the river.

Although a timber bridge was preferred, it was cost and schedule that would determine the material for the structure. The budget was approximately 3 million dollars. Stavibel, the engineering firm of this project, compared various systems and found a timber solution to be the best. A steel solution was considered, but would have cost slightly more. A concrete solution was also considered, but, due to prefabrication manufacturing limitations, was not realisable and had to be eliminated as an option.

3.2. Bridge Overview

The structural system chosen was a simple beam with camber spanning 67.5m. One support was held vertically and horizontally along the beams length and width. The other support was held vertically and horizontally along the width of the beam only. Due to manufacturing (max glulam length = 24m) and shipping limitations, it was decided to add two joints at third points as seen in image 17 to avoid a joint in the center of the bridge.

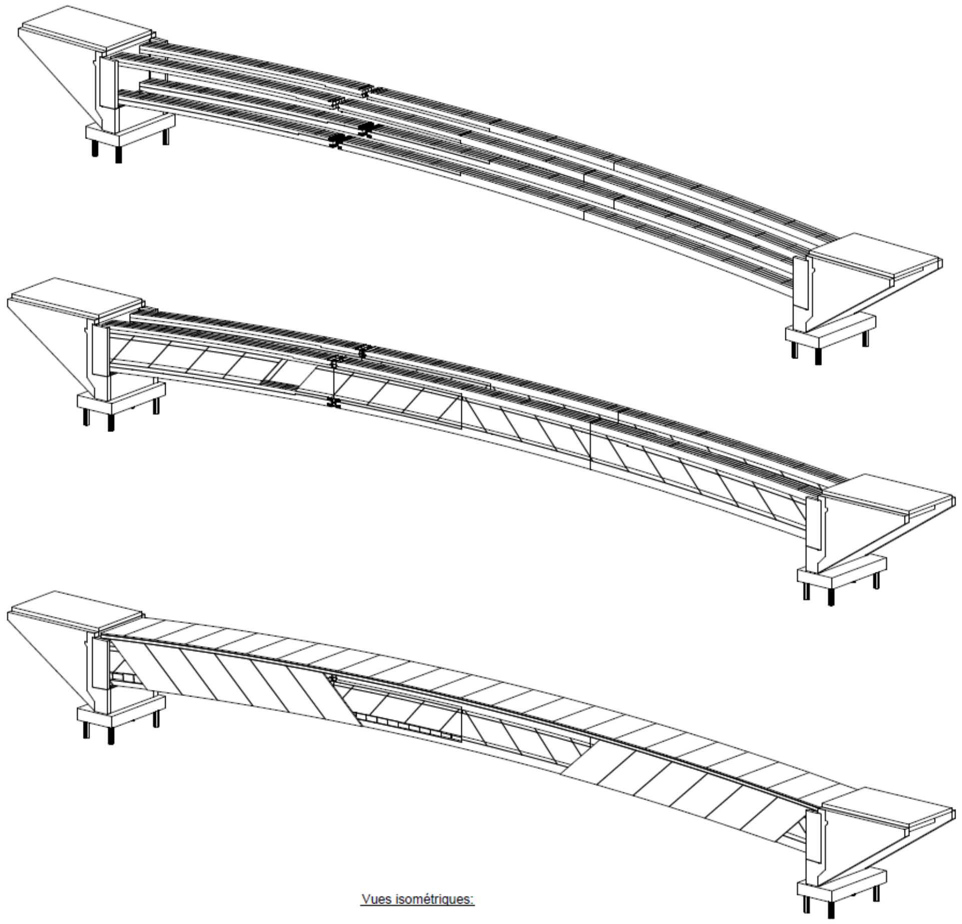
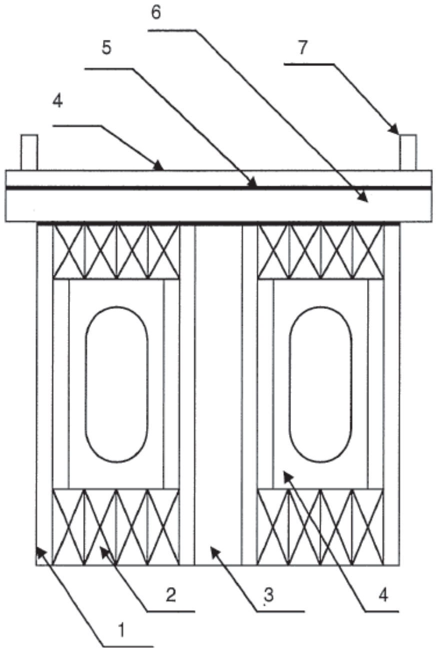


Image 17: Overview of bridge: Top: Glulam flanges (with transportation joints), Middle: Interior web added, Bottom: Exterior web and diaphragm added

The bridge is built primarily of glulam and cross-laminated timber. The primary structure consists of two large box beams that are each made up of block-glued (4 members) glulam flanges and cross-laminated timber webs. The exterior webs are fastened to the flanges directly with self-tapping screws and the interior webs are fastened via a steel part that is attached with self-tapping screws and annular ring nails. (See image 19)



- Two curved box girders which have glulam members for the top and bottom chords (2),
- Cross-laminated timber (CLT) panels connecting the top and bottom chords (1),
- Cross-laminated (CLT) panels used for the diaphragms and deck (3), (4), (6),
- Plywood panels used for the system of deck (non-structural) (5),
- Spruce pieces to cover the deck (4),
- Wheel fender (7).

Image 18: Section view of bridge (Reference: Stavibel)

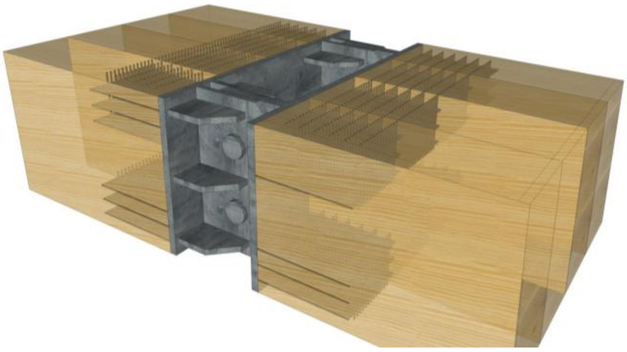


Image 19: Top: Overview of typical connections, Bottom: Bottom flange transportation joint

The transportation joints were made with self-tapping wood-steel screws for the bottom flange (tension) and bolts for the top flange (compression). On site, four pins per flange were installed in the steel-steel connection in order to connect the elements together.

3.3. Fabrication

Image 20: Prefabrication in the factory

Since the bridge has two box beams and two joints along its length, a total of six prefabricated elements were prepared in the factory. Everything that was possible to install in the shop was done so in order to make the on-site installation process more efficient.

3.4. Transportation and Installation

Image 21: Transportation of the individual elements

Each element was transported individually to the construction site. Not only was the size of the project a challenge, but so were the conditions. The installation began during the first days of February, the coldest time of the year.

A temporary island and two temporary bridges were constructed on site. This was necessary for the installation process. The middle span of the bridge was first installed on the island. The exterior spans were then dropped in to place. To insure that the pins would be perfectly aligned, steel beams were temporarily welded to connect the bottom and top flange transportation joints. Once the pins were installed, the steel members were removed.

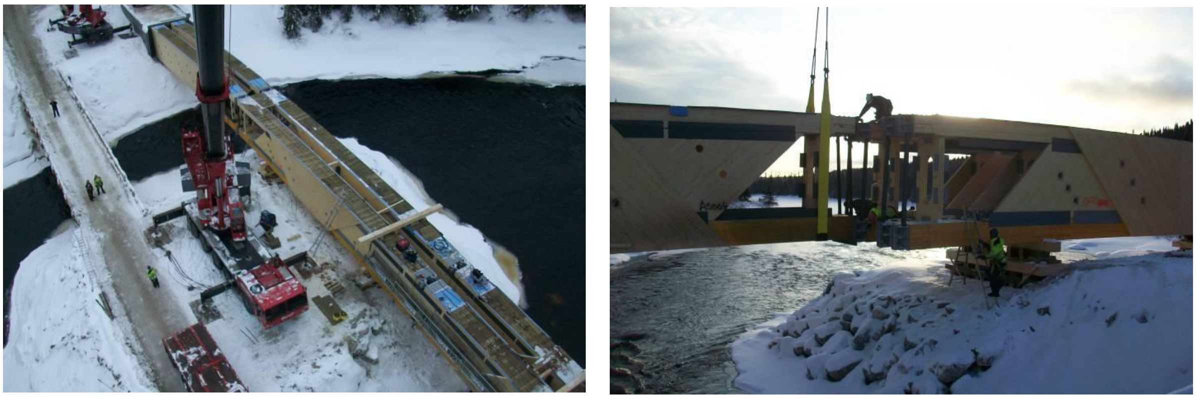


Image 22: Installation of the individual elements in extreme winter conditions

After installation of the main structural elements, the remaining web members (CLT panels) were installed. The diaphragm and the rest of the bridge build-up were then installed on top of the structure. Once completed, the sides still needed to be protected from the elements. Vertical zig-zag strapping was attached to the structure which was then covered with a horizontal spruce siding. The strapping had a significant depth to allow air to flow throughout the main structure. The web members also had holes to allow air to flow into the center of the box beams. All of the box beams can be accessed from either end. On a regular basis, as part of the maintenance plan, someone can walk through both box beams to check for any possible changes that could have an effect on the bridge’s structural integrity.

Image 23: Installation of the exterior siding to protect against the elements

3.5. Conclusion

The Maicasagi bridge was a successful project in the sense that using timber was the best, or only solution. By using Nordic’s available products, a relatively simple structure, designed to carry an impressive 1800kN traffic load, was realized to span almost 70m. Extreme winter conditions and a tight project schedule didn’t stop the project from being built. By March 2012, according to schedule, the temporary bridges and island were removed.

Deflection test were performed to compare actual values to the engineer’s predicted values. They matched perfectly.