Nancy Pauw Bridge | Completed 2022

History and Background

The Town of Banff is nestled into a valley of one of the most picturesque locations in Canada's Rocky Mountains. Given its natural beauty among towering mountains, it is one of the most sought out tourist destinations in North America, visited by more than 4 million people annually. It is also located in Canada's first national park, which the town took its name from, being established in 1887. Through this town, which is very conscious of representing its place in the park, flows the aquamarine, glacier-fed Bow River.

Until 2013, the only crossing of the Bow River at Banff was the historic stone-clad road bridge, which also carried the large flow of pedestrians visiting the various sites. But already by 1914, to make better connections, planners had in mind a footbridge to be located at Central Park, immediately adjacent to the town centre, 200 m upstream from the road bridge. That wish was not to come true for over 100 years.

Figure 1 - The Town of Banff in Canada's first national park.
Credit: Paul Zizka Photography

In fact, a more pressing expedient for the town arose in 2011, when it was discovered that sanitary pipes installed below the riverbed in the 1950's, at a location downstream from the road bridge, were in peril of being exposed, and needed replacing. This was accomplished along with the installation of a new timber footbridge in 2013, the pipes now being carried below the bridge deck. StructureCraft was also engineer and builder for that structure. But the desire for a footbridge at Central Park remained. In fact, pedestrian and cycling demand was only increasing. An attempt had been made to create this crossing in 2007, but the technical challenges were deemed too difficult, and the project was abandoned.

However, a new opportunity recently arose through a private donation offered by the Wim and Nancy Pauw Foundation, along with funding by various levels of government, including the Town of Banff, who was the project client, procuring the bridge through a design-build competition. The new bridge is named after the late Nancy Pauw, a long time Banff resident and hiking/cycling enthusiast.

Figure 2 - The glacier-fed Bow River flanked on either side by parks and attractions.
Credit: StructureCraft

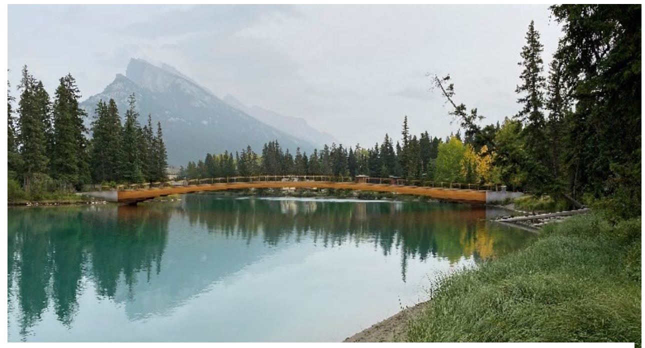

Figure 3 - Initial render of the clear span, low profile Nancy Pauw Bridge.
Credit: StructureCraft

Site Challenges

The Bow River is pristine, and carefully guarded by both Parks Canada and the town. Environmental concerns, both permanent and during construction, were paramount. The bridge needed to be a clear span to minimize impact on the river. It needed to be low profile with minimum slopes for user accessibility, and minimal ramping on either side to mitigate impact on the park lands. Yet it needed to give clearance for flood conditions and not alter the paths of the ever-present elk which freely cross the river here. And the banks of this glacier-fed river are nowhere very high.

As with the 2013 crossing, the desire was for a bridge which was graceful, unobtrusive, and natural, fitting in with both the beautiful surroundings and the town's defined Rocky Mountain theme. Also important was allowing users unimpeded views while crossing. The architectural theme clearly suggests the use of wood and stone. And this was to be a high-profile civic structure with up to 10,000 users per day.

With all of these constraints, the solution needed to be extremely slender, with an 80 m clear span to avoid work in the river. And there was no room for backspans. Could this be done elegantly with any material, let alone timber?

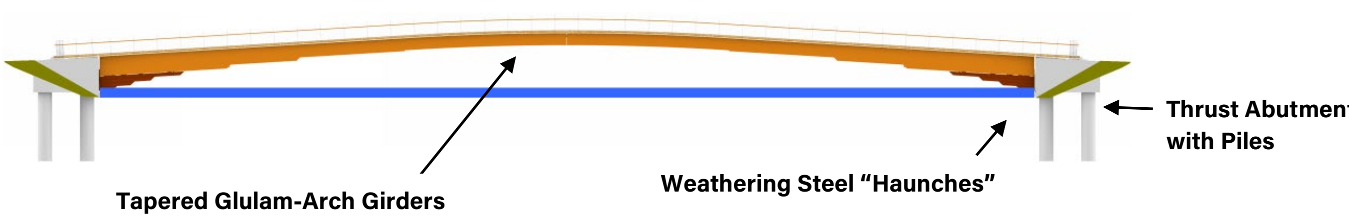

Figure 4 - A 3D Model showing the low profile of the bridge in relation to the embankments.
Credit: StructureCraft

Figure 5 – Looking across the Bow from Central Park. Here the river slows, and its banks are quite low.
Credit: StructureCraft

Solution and Analysis

StructureCraft had been thinking about this challenge since its work on the 2013 bridge. In fact, it would be natural to make this bridge a sister in character. But the only solution, especially with timber, appeared to be a shallow arch. And with a 5% max slope at the abutments, and the required clearances, the arch could only have a rise:span ratio of about 1:20, inviting all the challenges of a very shallow arch structure, namely:

- non-linear behaviour
- potential for snap-through buckling
- large abutment thrusts
- susceptibility to unsymmetrical loading
- and difficulty with understanding the vibration characteristics.

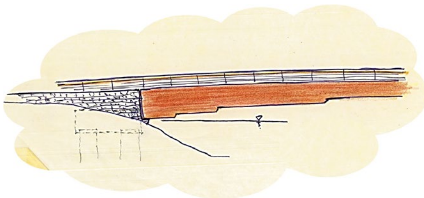

Figure 6 – Early sketch of the abutment and bridge.
Credit: StructureCraft

To understand if this solution was possible, the first challenge needing investigation was soil conditions. Could they resist the enormous thrusts required, including the permanent dead load thrusts? These could increase over time due to creep in the timber structure and be magnified by non-linear effects (a kind of "ponding-like" instability). The soil profile was dense sedimentary but the complex effects needed to be confirmed through full soil-structure interaction analysis. We chose a grouping of 5 - 1.2m diameter cast-augured concrete piles to resist the full unfactored 4000 kN thrust with minimal horizontal deflections (approx. 15mm including non-linear effects).

Proportions of the structure were selected for elegance of form and efficiency. Diagonal steel bracing links the two pairs, creating the diaphragm to resist lateral movements.

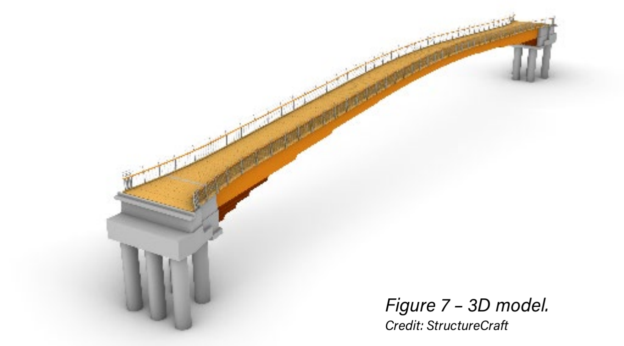

Figure 7 – 3D model.
Credit: StructureCraft

It was desired to create the natural form of a tapered arch, minimizing depth for greater clearance at midspan, and maximizing depth at abutments, much like the many beautiful stone arches of the past. But like the early stone arch designers we wanted to use the mass stiffness of the abutments to assist with the global structural action and unbalanced loading effects, essentially creating fixity at the supports. Abutments consist of a 1.5m deep pile cap and the large diameter piles, 10m in length, socketed into the stiff soil. Tapered weathering steel "haunches" were anchored to the abutments both to add stiffness and to protect the timber from the river. Straps from the top of the timber were affixed to the concrete abutment, in this way creating the fixity.

Vibration Control

The most difficult aspect of slender bridge design is vibration performance. We found with the shallow arch design that it was difficult to predict the natural frequencies, and they were close together, even compounding each other. A central tuned mass damper was used, like the previous bridge, consisting of a simple mass of steel plates on a carriage suspended from cables stretched to four points on the girders. A unique feature of this design is that we were able to tune it to both walking (1.9 Hz 1st vertical) and jogging (2.4 Hz 1st torsional) frequencies. In the first case the mass moves vertically, and in the other it moves laterally, efficiently suppressing the large accelerations experienced initially in both modes. But it remains a somewhat "lively" bridge.

Figure 9 - The completed bridge was measured using accelerometers prior to installation of the TMD.
Credit: StructureCraft

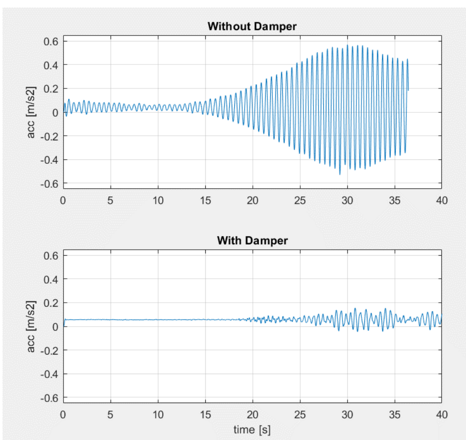

Figure 10 – Response to resonant input (1.9 Hz).
Credit: StructureCraft

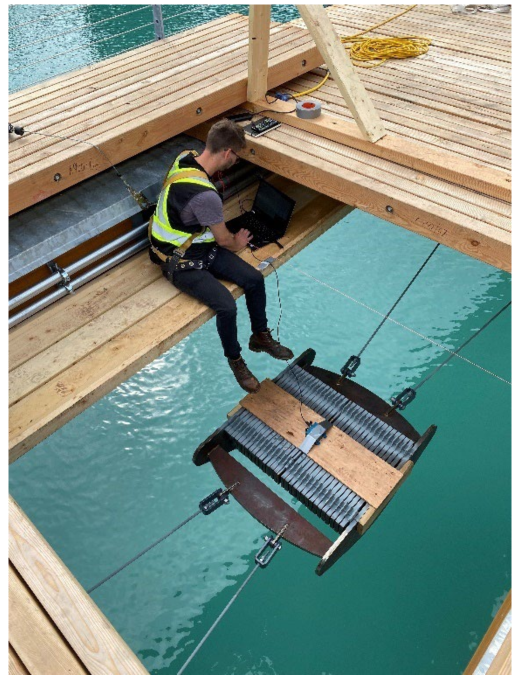

Figure 11 - A single central tuned mass damper was suspended from cables.
Credit: StructureCraft

Guardrails and Decking

As mentioned, the bridge design needed to be simple and unobtrusive, allowing users to experience both the scenery and the river. Materials needed to be natural and durable. Great thought and care had been taken with the guardrail and decking system of the earlier downstream bridge, and it had performed very well in the 9 years preceding this bridge. So it became obvious to do the same again.

The tapered guardrail stanchions are hot-dip galvanized, and prestressed 6mm diameter stainless steel cables run through grommet protected holes in the stanchions.

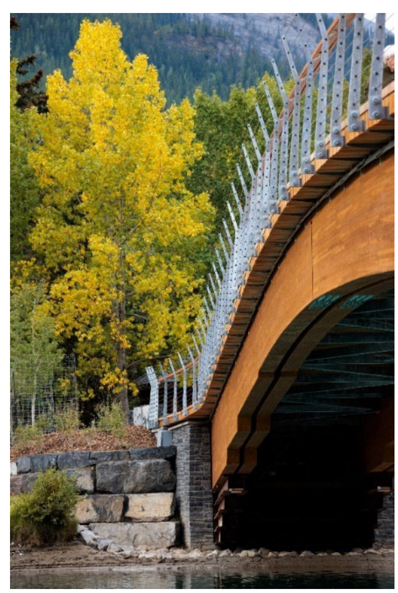

Figure 12
Credit: Paul Zizka Photography

Figure 13 - Installation of conveniently replaceable timber deck panels.
Credit: StructureCraft

Decking consists of spaced Douglas Fir timbers prestressed into 1m wide removable panels using galvanized rods and rubber spacers.

Fabrication and Installation

As with all longer span bridges, design must respect erection and fabrication considerations, and the site. How to least disturb river, national park, and town, considering seasonal issues and low/high water levels? Environmental impact assessments and approvals at numerous levels needed to be procured. All of these were managed under the design-build contract, and the client was very cooperative in assisting to ensure the critical timelines were met.

Piling was conducted in December, at low water but prior to deep freeze. Abutments were formed and poured in April, before water levels started to rise.

The 8m long tapered weathering steel haunches, complete with 35mm diameter rebar embeds, were surveyed and cast in at this time. These act not only to stiffen the span, but as receivers for erection of the timber bridge girders.

Figure 14 - Weathering steel "haunches" ready to receive bridge sections. Credit: StructureCraft

Figure 15 – South section ready for install. Note central pin connection and straps for moment continuity.
Credit: Paul Zizka Photography

For spanning the river, the erection scheme chosen involved installing concurrently two – 40m long bridge sections, 32,000 kg each, with a central tight-fitting thrust hinge, which was later fixed using straps.

To minimize handling, the long tapered glulam pieces were fabricated and coated at the glulam plant and transported directly to site. They were assembled on shore into two half-bridge sections in preparation for erection.

Figure 16 – The central hinge locks the two bridge sections together. *Credit: Paul Zizka Photography*

Figure 17 – Bridge sections were erected concurrently. *Credit: Paul Zizka Photography*

By its nature the shallow arch design demands extremely tight tolerances. Small horizontal displacements create large vertical movements, and the bridge geometry was critically dependent on a tight fit.

Figure 18 – Cinching South Section to abutment. Note also pre-deflected clamping plates. *Credit: StructureCraft*

Erection of the bridge sections (with activation of arch thrust) was carried out in a matter of hours, and horizontal and vertical deflection measurements, even after set was achieved, were smaller than anticipated.

Conclusion

The Town of Banff is thrilled to have their nearly 110-year-old dream come true. The new footbridge crossing is now prized as a beautiful accent in this most picturesque setting, and will be a popular (and lively) connector for both townsfolk and the many visitors for generations to come.

Figure 19 – User experience was a most important design goal. At the Grand Opening, hundreds walked, jogged, and jumped on the bridge. *Credit: StructureCraft*

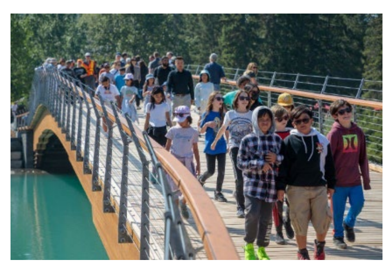

Figure 20 – Among the first to cross the new community bridge were the Banff Elementary School students. *Credit: Town of Banff*

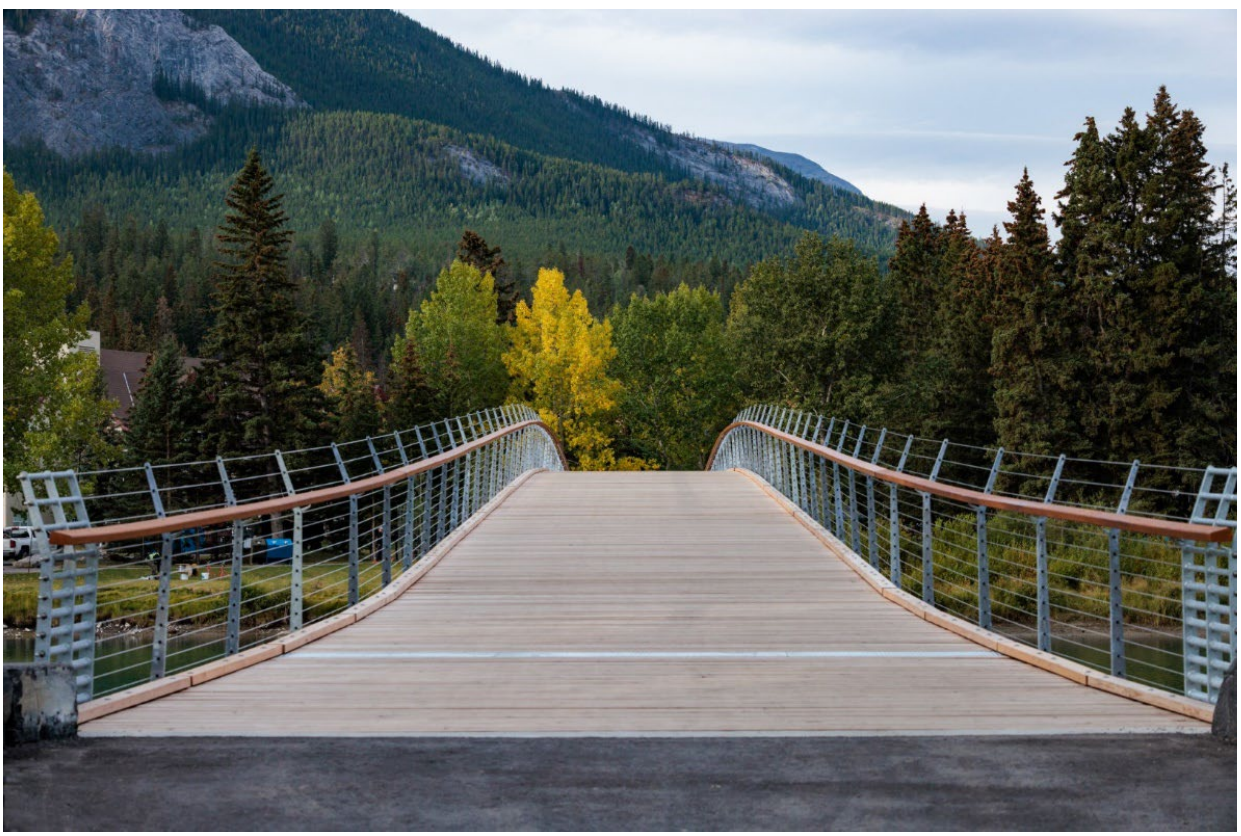

Figure 21 – Photos of completed bridge.
Credit: Paul Zizka Photography