ST. PATRICK'S BRIDGE

2015 Canadian Consulting Engineering Awards Submission
Transportation Category

Image by Yellow Couch Photography;
Extended in courtesy by Calgary Municipal Land Corporation

Halsall RFR

St. Patrick's Bridge, Calgary 2015 CCE Award Submission

Submitted to Canadian Consulting Engineers
Submitted by Parsons Brinckerhoff Halsall

Project Information

Project Name: St. Patrick's Bridge
Project Location: Calgary, Alberta
Completed By: 10/2014
Category: B. Transportation
Entering Firm Name: Parsons Brinckerhoff Halsall
Firm Address: 2300 Yonge St., Suite 2300, Toronto ON M4P 1E4
Project Role: RFR, prime consultant performing project management, architectural design, structural engineering; Parsons Brinckerhoff Halsall, subconsultant performing structural engineering and field engineering
Member of the (ACEC)?: Yes

Contact 1 Name: Lauren Klostermann
Contact 1 Tel: 416.644.0652
Contact 1 Email: lklostermann@halsall.com

Contact 2 Name: Chris Love
Contact 2 Tel: 587.390.8206
Contact 2 Email: clove@halsall.com
P.Eng: Yes

Summary

St. Patrick's Bridge spans the Bow River in Calgary's East Village, linking St. Patrick's Island with the East Village mixed-use community development to the south and the popular pedestrian paths and communities along the Bow River to the north.

It is a three-span, 182-metre long network arch structure likened to stones "skipping across the water." Given its slender and architecturally-unique design, the bridge had to overcome several design and construction challenges, including the Calgary flood of June 2013.

The bridge spans Calgary's Bow River linking St. Patrick's Island with the East Village.

Innovation

St. Patrick's Bridge consists of three continuous, slender steel arches forming a network arch system with the post-tensioned concrete deck serving as the arch tie. The network cable arrangement permits the deck and arch to work together to resist asymmetric loading, thereby creating an efficient and streamlined structure.

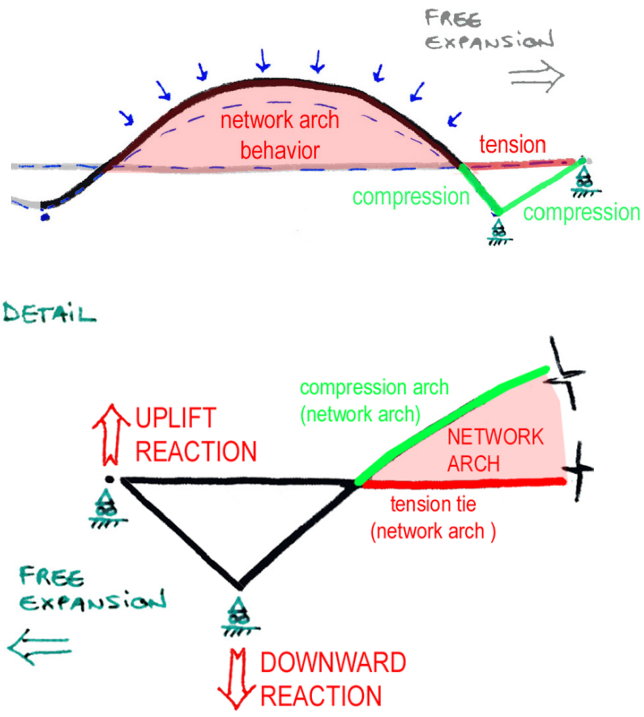
The arches rise over the deck on the two river spans, leaning inwards to facilitate bracing, while the open cable network permits views through the structure. On the island, the arches stay below the widened deck, providing a completely open viewing platform.

To optimize efficiency and economy of the bridge's slender structure, the design team used cutting-edge software to undertake a series of parametric studies of the arch geometry. Rhino was used for the geometric modelling of the bridge structure, and Grasshopper was used to allow parametric modelling while updating the Rhino model in real time. Numerous studies were done for the geometry and layout, including the rise-to-span ratio of each arch, arch inclination, and hangar cable layout.

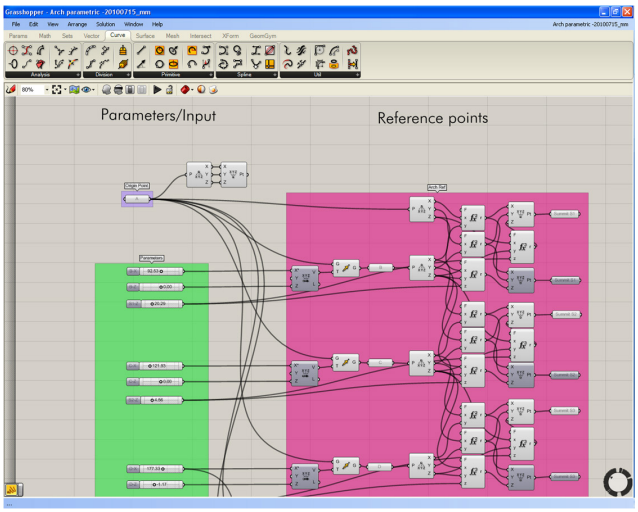
Oasys GSA software was used for the structural modelling, and Geometry Gym's Smart Structural Interpreter (SSI) was used to facilitate importing the parametric geometric model with the touch of a button. This allowed for a quasi-instantaneous evaluation and optimization of the geometric parameters.

The structural scheme of a network tied arch allowed the arch and deck to function together as one large truss, using much more slender members than would be possible with a traditional arch and vertical hangers. The lightness of the structure allowed for a maximum of prefabrication, reducing on-site construction and increasing quality. The result of this optimization is a landmark pedestrian bridge that is nearly half the cost per square meter of other signature bridges in Calgary.

Structural Solution to resolve de-tensioning problem



Screenshot of Grasshopper parameters



Complexity

River hydraulics: The bridge deck could not touch down on the island as the surface is below the 100-year flood level. To minimize the impacts to the river, foundations were kept out of the affected areas and access to the island was accomplished by providing an access ramp which has piers and abutments constructed of concrete on deep foundations to resist scouring.

Weather restrictions: The bridge was designed so that many elements could be prefabricated off-site. This limited construction delays due to weather and ultimately improved the quality of the end-product.

Construction Challenges: To ensure that the arches and deck would work together as a network arch, both the installation operations and hanger cable tensioning had to be carefully sequenced.

Calgary Flood: The flood of June 2013 caused severe damage to St. Patrick's Bridge while it was still under construction. The scaffolding supporting the deck was knocked out, causing considerable deck deflections. In addition to extensive concrete cracking, the steel reinforcing bars and post-tensioning strands had yielded.

As the post-tensioning strands spanning the deck's full length had been tensioned and grouted, it was necessary to remove the entire concrete deck. The south arch sections also had to be removed and reset since they were not fully welded into place before the flood, and their position had shifted.

To accommodate the flood-impacted schedule and partially-constructed bridge, all arches had to be erected and fully welded before the deck was complete. The goal was to have full load transfer of the deck to the arches before the next potential flood. Careful control during fabrication and erection streamlined the construction in spite of the devastating flood.

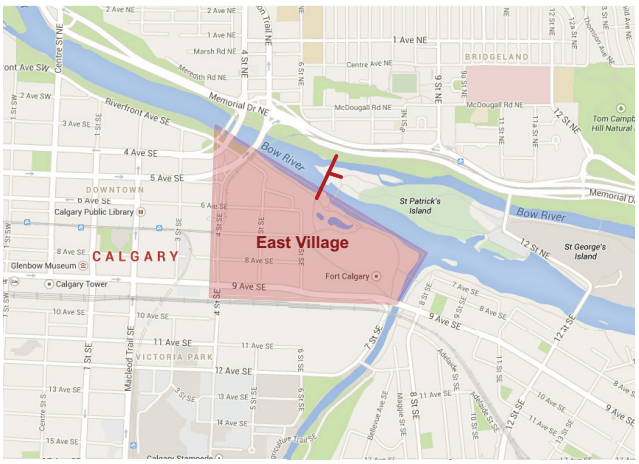
Erection of arch segments

Calgary flood

Social and Economic Benefits

St. Patrick's Bridge is a critical connector for the transformation of Calgary's East Village. Since 2007, CMLC has committed more than $357 million in investment into East Village infrastructure and has attracted over $2.4 billion of planned private development. Two new mixed-use/residential projects by pioneering developer partners, FRAM + Slokker and Embassy BOSA, will be completed this year and welcome close to 800 new homeowners into East Village. Two hotels have been announced for the community with one already under construction. As well, the community will be anchored by the National Music Centre, currently under construction, and construction on the New Central Library will begin later this year.

The bridge is crucial to the revitalization of the East Village



Environmental Benefits

St. Patrick's Bridge was designed to be as efficient and light as possible. The slender concrete deck design minimizes the total length of the structure and avoids long ramps at the approaches. This slender, efficient design reduces the use of building materials and minimizes the bridge's environmental impact, which in turn reduces the structure's carbon footprint.

The bridge footprint is also sensitive to river hydraulics. The surface of the island is below the 100-year flood level, so the bridge deck could not touch down on the island. Thus, the design includes an island access ramp. Scouring of the soils around the interior piers in the event of a flood was a concern that was addressed by supporting the foundations on deep concrete drilled piles. With no in-water foundations or piers, the bridge was designed to limit the impact on the river.

During construction, a gravel berm was placed in the river to support the scaffolding. This option was the least disturbing to aquatic life, as the alternative would have been a series of steel piles driven into river bed. The berm was partially left in place at the end of the project, providing fish with gravel necessary for spawning.

Bridge footprint is sensitive to river hydraulics, and a lack of in-water piers means minimal environmental impact

Meeting Client's Needs

St. Patrick's Bridge is the result of an international design competition launched by the CMLC in 2009. The client sought submissions from qualified candidates who could propose an innovative design with consideration for safety, budget, connectivity and aesthetics. The bridge would be a key connector for Calgarians entering East Village and Calgary's core from Bridgeland, Sunnyside and other neighbourhoods north of the Bow River. It would also bring visitors to the newly revitalized St. Patrick's Island Park (on track to open in summer 2015).

Calgarians were directly involved in selection of the final design: More than 2,000 of the City's residents provided online input on 33 international concepts. Through its elegant, yet economical design, the "skipping stone bridge" has more than achieved the CMLC's goals. Accessible to all users and designed to withstand the elements, the bridge is an important connector for many communities and pathway users throughout the City. Despite the setback of the June 2013 flood, the new bridge was delivered on budget and opened on October 20, 2014.

Bridge near completion

Rebar on bridge deck

Initial infill concrete pour

Bridge construction
and arch detail

Bridge near completion