Chaudière Crossing Bridge Rehabilitation

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Abstract: The Chaudière Crossing was the first bridge built over the Ottawa River and today provides a vital interprovincial transportation link between Ottawa, Ontario and Gatineau, Quebec.

The Crossing is an essential component of the National Capital Region economy as it is a primary commuter route between the cities of Ottawa and Gatineau, carrying approximately 28,000 vehicles daily. As such, this crossing cannot be closed to traffic nor is it feasible to replace structures. Therefore, structure rehabilitation is the only practical solution.

Public Works and Government Services Canada (PWGSC) was allocated $400 million over two years to repair Crown-owned public infrastructure such as buildings and bridges. While this presented a great opportunity for PWGSC to accelerate the rehabilitation of the Crossing, it also posed a challenge to complete a major project in a tight timeframe.

After much consideration, the solution selected was to re-line the existing arches with a series of precast arch elements and to grout the annulus between the host structures and the precast elements.

This case study examines the various aspects of this project from the initial stages of design, through the various solution options, to the development of the final solution.

More importantly, it explores the challenging manufacturing and construction operations that involved working with a series of large and heavy components, in a restricted space, over the Ottawa River.

With a restricted time schedule and the above noted construction constraints, the paper details how those major obstacles were overcome to complete this project on time and on budget.

Figure 1. Chaudière Crossing of the Ottawa River (c1915)

History: Commissioned by Colonel John By, the Chaudière Crossing, constructed between 1826 and 1828, was the first fixed crossing over the Ottawa River connecting Upper and Lower Canada and is located between what is now Ottawa, Ontario and Gatineau, Quebec. (Figure 1) The original crossing was composed of several stone arches connecting the various islands at Chaudière Falls with a timber arch over the main channel. Now managed by Public Works and Government Services Canada on behalf of the Government of Canada, the Crossing has evolved to a series of eight structures including two stone arches. Arch No.1 was built in 1847 and Arch No.3 was built in 1827. (Figure 2)

The Chaudière Crossing is an essential component of the National Capital Region economy as it is a primary commuter route between the cities of Ottawa and Gatineau. It is one of five bridges connecting Gatineau and Ottawa and is one of the two bridges designated for truck traffic. It is a vital commercial link carrying 15% of all daily traffic between the two cities and 42% of the truck traffic between Quebec and Ontario.

During what was expected to be a routine repair contract in December 2008, inspectors discovered that the deterioration of the stones of Arches 1 and 3 was more extensive than had been identified in the original inspections. These masonry stone arches were built more than 160 years ago. A combination of time, weather, and winter-related factors contributed to major deterioration of the stonework. Stones which were originally some 750mm thick had experienced 200mm to 250mm of deterioration. In addition, there was cracking in some stones causing large rock fragments to fall into the river. Immediate repairs were done, but further studies showed that a substantial rehabilitation of both arches would be required within a year.

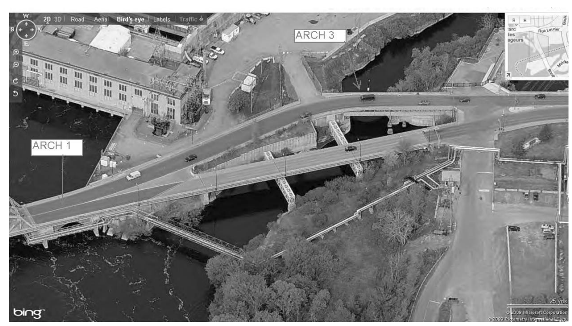

Figure 2. Aerial View of Site

A design contract was awarded to Genivar in June 2009. Following a competitive tendering process, a construction contract was awarded to

Construction Kiewit CIE in October 2009.

Design: As the crossing is a vital link in the transportation network between Ottawa and Gatineau, it simply could not be completely closed to traffic. Due to the location of Arch 1, it was not feasible to construct an on-site detour to allow replacement of the two structures. Therefore, rehabilitation of the masonry arches was the only option remaining.

Numerous options were considered by the Owner and Genivar, the owner's Consulting Engineer. Key elements to this rehabilitation project included keeping the Crossing open to traffic and limiting construction access to the roadway while maintaining water flow. Preserving the existing ecosystem and the original bridges' structural characteristics were also priorities.

The chosen solution was to construct concrete arch liners on new footings inside the existing stone arches. The contract documents were prepared to allow either a cast-in-situ concrete or precast concrete solution.

The successful contractor, Construction Kiewit CIE chose to proceed with the precast concrete option with Armtec Infrastructure as the precast supplier.

Manufacturing: Historically, Armtec is known across Canada for a wide range of corrugated steel and geosynthetic solutions. In the past few years that all changed as precast facilities were acquired across Canada.

Originally it was anticipated that Armtec, as suppliers of Bebo precast concrete arch bridges, would provide a standard Bebo arch shape for both structures. However, doing so would not have met the project's geometric requirements. As a result, custom designed and manufactured Bebo arches were produced for this project.

Armtec's engineering team determined that the mass of the proposed shapes was such that it was not feasible to manufacture them as proposed in the tender documents. Therefore, it was recommended to raise the top of footing elevation of Arch 3 in order to reduce the dimensions and subsequent weight of the precast elements.
For both shapes, the arch thickness was also reduced from 400mm to 300mm in order to further reduce the weight per piece.

A detailed digital survey of the existing structures provided assurance that the proposed shapes were appropriate for the actual openings.

Once the detailed design of Arches 1 and 3 was accepted by Public Works and Government Services Canada, the next step was production. Although consideration was originally given to providing two piece arch elements, the arches were ultimately cast as single leaf units that would span from footing to footing.

The casting of these heavy units (24.8 metric tonnes) was carried out at Armtec's Ottawa precast plant located approximately 20 kilometres from the site. Arch 1 elements had a span of 12.0 metres and a rise of 4.5 metres. Each of the 7 pieces had a lay length of 2.04 metres.

Arch 3, comprised of 5 sections, had a span of 15.5 metres, a rise of 3.87 metres and a lay length of 1.66 metres.

Both arches were dimensionally unique, so a custom form was required for each of the two shapes. A single steel form, which was modified to suit both arches, was produced in-house by the precaster. (Figure 3) Preparation and pouring of each arch section took approximately two days.

Figure 3. Preparing Form

After that time period, the arch section was removed from the form, then moved to the storage yard (Figure 4) and preparation began for the next pour. These units were manufactured using regular stainless steel rebar and 45MPa concrete. Added features to the basic arch were restraint cables to limit flexure and in turn damage to the individual arch sections during handling and erection. As well as lift points, pull points were also installed to assist the contractor in locating the arches in their final position in the field.

Figure 4. Moving Arch to Storage Yard

Construction: After mobilization in February 2010, the first step was de-watering of the Arch No.1 site. This was accomplished by constructing sheet pile coffer dams spanning between the existing arch foundations, upstream and downstream of the arch. Since the stream bed in this location was bedrock, the sheet piles were supported by steel frames and sealed to the bedrock by the pouring of tremie concrete.

The original stone footing was examined for serious flaws and any required repairs were undertaken before construction of the new footing commenced. This new footing was anchored to the bedrock via dowels. In both cases, temporary steel frames were constructed and connected to the upstream face of the new footing in order to create a landing area for the new arch sections.

Erection: Upon arrival at the site, arch sections were leapfrogged into place by first moving the arch and then the crane along the roadway as space did not permit unloading the precast section at the final pick point.(Figure 5)

Figure 5. Leapfrogging of Crane and Arch into Position

Once both the crane and the arch were in the proper position on the existing bridge deck, the arch was hoisted and rotated into its proper orientation and the installation of the stainless steel rebar required for the annulus was completed. (Figure 6)

Figure 6. Rotating Arch Segment

The precast segments were then lowered over the side of the bridge onto a sophisticated roller system installed on the steel frame footing extension. (Figure 7)

Figure 7. Landing on the Rollers

Pulling of the segment into position was achieved via a single cable and winch. Kiewit engineers designed a system of pulleys and cables that ensured that both sets of rollers moved in tandem with no racking of the arch. (Figure 8)

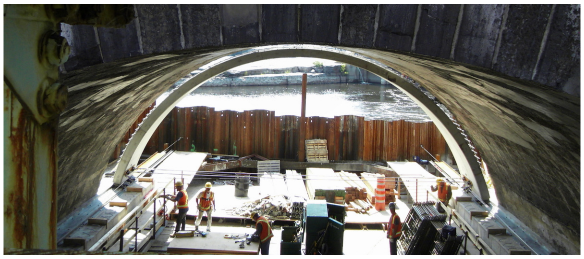

Figure 8. Pulling First Arch Segment into Arch 1

Once the arch segment was in its final location, it was jacked up, the rollers removed, and the arch was lowered onto concrete shims. This process was repeated for the seven sections on Arch 1 (4 day duration) and the five arch sections required for Arch 3 (completed in 3 days). Although work was carried out from street level, at least one lane of the road and the pedestrian sidewalk remained open to traffic at all times.

Both structures received new cast in place spandrel walls prior to the annulus being filled with 35MPa concrete.

Conclusion: This project was undertaken under very tight time and space constraints. The innovative use of precast concrete arches allowed the rehabilitation of these bridges in record time with minimal disruption to the travelling public. Creative problem solving throughout the life of the project led to a successful outcome from both a time and budget perspective.

The ultimate success of this project can be attributed to the co-operative efforts of all of the contributing parties.

Figure 9. – Completed Structure - Arch 3

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