ASSOCIATION OF CONSULTING ENGINEERING COMPANIES | CANADA
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Ottawa

Vimy Memorial Bridge

Ottawa, Ontario

- Unique iconic bridge meeting the requirements of UNESCO World Heritage Site and National Historic Site.
- A positive social and environmental effect by means of a bridge intended to inspire and interest the public.
- Attention to aesthetics both globally and in detail to create a structurally sound engineered and aesthetically pleasing bridge.

PARSONS

Project Description

Parsons was retained by the City of Ottawa to create a design for a new bridge crossing the Rideau River and hence connecting the urban communities of Riverside South and Barrhaven in the South of Ottawa. The Rideau River at the bridge location is part of the Rideau Canal System, a recognized National Historic Site in Canada and a UNESCO World Heritage Site.

The design had to be compatible with the UNESCO World Heritage Site designation as well as meet the stringent design guidelines set by the City of Ottawa and the various approval agencies, including the National Capital Commission, Parks Canada, the Rideau Valley Conservation Authority, First Nations (Algonquin of Ontario), Transport Canada, and Transport Canada Marine. An overhead structure comprised of tubular triple arches that clear spans the waterway with a 125m main span exceeded the imposed design requirements and resulted in an iconic gateway structure that provided an integrated net positive environmental effect from the natural, social, economic, and environmental perspective. This bridge is unique and first of its kind in North America with triple tubular steel arches supporting a suspended deck using inclined hangers.

As Prime Consultant, Parsons provided services including concept design; preliminary design; final detailed design; and contract documentation, inspection, and engineering services during construction. The scope of engineering disciplines included bridge, transportation, traffic, drainage and electrical engineering, as well as environmental services, including liaison with various key stakeholders to obtain the required approvals.

Innovation *Briefly introduce your project, i.e. what was done and why? Then explain how the project demonstrates the innovative application of engineering principles or techniques. How is it distinguishable from similar projects of its type?*

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The objective of this project was to create a bridge that would satisfy the functional as well as the many mandatory heritage, environmental, and aesthetic requirements relevant to such an important cultural and historic location. The functional design requirements involved spanning an 80m-wide waterway while accommodating a 45m-wide by 6.7m-high navigation envelope, providing a 3.0m clear height above a pathway on the west side and carrying a 40.6m-wide bridge deck cross-section comprised of eight lanes of traffic, including two dedicated bus rapid transit lanes, two bicycle lanes, and two pedestrian walkways. The aesthetic design guidelines developed for this crossing by DTAH Architects and adopted by the City of Ottawa included requirements for a distinctive new bridge in a natural setting that is pleasing to the eye from a distance and up close, by day and night; exhibits an appropriate landmark quality that responds to the significance of the Rideau Canal and is harmonious with its picturesque natural setting; responds to the history of engineering innovation and evolution of high quality bridge design on the Rideau Canal, yet is an expression of its own time; creates a safe, enjoyable, and memorable experience for users, both on the bridge and under the bridge; and maximizes transparency and openness. Furthermore, the National Capital Commission provided input on the features that were considered appropriate and desirable for this crossing, including: “astonish and inspire viewers, in the round”; enhance the experience of using the Rideau Canal; avoid heaviness; reduce the apparent scale of the bridge; explore ways for natural light to penetrate the bridge; consider the bridge as a possible gateway to the National Capital of Canada; and use naturalistic landscaping and enhance the experience of walking by the riverbanks.

In developing a structure that addressed these constraints, it was clear that the new bridge should keep out of the river, enhance the total environment, and address the issues posed by a very wide deck. Having the bridge main span clear of the waterway—including during high water events—while keeping all permanent construction out of the river, was a key factor in facilitating approvals from the various authorities responsible for the river and for the environmental features of the river, including the fish. Furthermore, it was realized that a wide bridge at this site cannot blend with the natural environment of riverscape and treed lands. Instead, the goal was to enhance the environment, creating a bridge that is respectful of the river, and is deemed to be a feature of particular significance and beauty. In the context of a bridge that is very wide compared to its span, design studies showed that it would be beneficial to separate the roadways from the sidewalks, and to separate the roadways from each other, hence giving rise to three open-air slots within the bridge. These slots allowed light to penetrate the deck in a substantive way across the full length of the bridge and at several locations across its width, effectively downplaying the fact that the bridge was in the order of magnitude of a football field of deck over a waterway that was to be treated with sensitivity.

A range of superstructure types was considered, developed, and reviewed. These included a suite of options including above-deck structures (such as cable-supported bridges, arches, and trusses), and under-deck structures (such as concrete girders, steel girders, and arches). Several overhead arch configurations were tried and ultimately the scheme adopted was inspired to some extent by the Lusitania Bridge in La Merida, Spain, an elegant but quite different bridge designed by Dr. Santiago Calatrava. The three slots noted above were intended to allow light to penetrate the bridge deck and were very compatible with three overhead arches. One arch was located centrally between the two vehicular travelled ways, and the other two arches were located between the vehicular travelled ways and the sidewalks. This triple overhead arch configuration was found to be very much lighter, open, airy, and pleasing to the eye than any under-deck bridge we could envisage. As a result of detailed review by the City of Ottawa, the National Capital Commission, and many other approval agencies (including those responsible for safeguarding the United Nations' interests at this World Heritage Site), the configuration was deemed to meet virtually all of the many agreed-upon principles and guidelines. The triple vertical arch scheme was considered to provide an appropriate landmark bridge configuration responding to the significance of the Rideau Canal. It was found to be harmonious with its picturesque natural setting and, perhaps most importantly, to potentially "astonish and inspire" those who viewed the bridge from whichever location, whether on land or water. The design met with great enthusiasm from all approval agencies and the public.

The project was designed with a high degree of technical excellence and the design team believes that it was successful in reaching its goals of accommodating the functional requirements that necessitated a very wide deck cross-section, while also meeting the stringent aesthetic requirements and producing a net positive environmental effect. Key innovations used on this project achieved the following:

- The bridge was designed for a 100-year service life, using a combination of proper detailing, durable materials, and detailed quality control measures.
- The bridge design, which is comprised of three independent tubular arches supporting a suspended deck system using inclined hangers, is unique and the first of its kind in North America.
- The freestanding tri-chord true arches are efficiently designed and rely on the inclined hangers, which significantly contribute to the arches' transverse stability by engaging the weight of suspended deck. The hangers are attached to the steel grillage supporting the concrete deck and transfer the loads from the deck to the arches.
- The hanger system comprised of multi-strand cables and anchorages with adjustment nuts allows for quick and easy adjustment of the cable forces. This proved useful during construction and limited the cable adjustment process to a few days in comparison to several weeks for alternative systems.

- In addition to being aesthetically pleasing, the arch tubular members are highly durable as they are completely sealed to the elements. To enhance durability, a four-layer coating system was applied to the arches with stringent quality control requirements in the fabrication shop and on site.
- The arch tubular members provide structurally efficient details and cross-sections.
- Closed elements were used to the maximum extent possible in order to conform to the requirements for long life and maximum durability. Galvanized reinforcing steel was used in the deck for durability.
- The lighting scheme serves a dual purpose of directly lighting the roadway and sidewalks and indirectly illuminating the arches by reflecting the excess light using deflectors attached to the light fixtures.

The design paid attention to aesthetics both globally and in detail to create a structurally sound engineered and aesthetically pleasing bridge with the optimum in sustainable features.

Complexity *Explain any extraordinary problems and conditions that were overcome.*

The complexity of designing the Vimy Memorial Bridge arose from the disparate requirements of accommodating a very wide deck, and the requirements to develop a light, airy, and transparent structure. This challenge was turned into an opportunity by introducing three slots through the deck, which in turn were used to accommodate the arches. Furthermore, a gentle horizontally curved alignment was introduced into the sidewalks on the outside of the arches to afford the bridge additional elegance and to complement the curvilinear nature of the arches. Additional project design complexities included:

- Meeting the requirements of the various approval agencies is a major challenge for most bridge structures over waterways. This was addressed from the beginning by the design team by selecting a design that totally avoided interference with the waterway and that met the environmental criteria set down by the various parties to the project.
- Due to the geometry of the tri-chord arches, the design of many of the tubular connections is not covered in the traditional literature or in codes. As such, it was necessary to construct finite element models to determine the adequacy of these connections.
- Bending the tubular arch chords, which varied in thickness from 28mm to 76mm, is not conventional and required detailed specifications and testing requirements to ensure that the pipe material properties were maintained and were not adversely affected by the bending process.
- Design of the deck structural steel grillage system, which is 143m long and varies in width from 54.6m to 59.2m, had to consider transportation, erection, and long term durability. This was achieved by using completely sealed steel boxes for the transverse floor beams, which are the main structural members, and bolted connections for secondary longitudinal stringers. Each floor beam was designed with one splice in the middle and with one half on the adjacent stringer welded to it, to accommodate ground transportation.
- Construction was delayed by the general contractor going into receivership and another contractor hired by the bonding company completing the job. This significantly complicated Parsons' engineering services during construction, but without compromising the quality of the final product.

Social and/or Economical Benefits *Explain the social and economic benefits to society provided by your project. Be specific and provide qualitative and quantitative information.*

The bridge is making important contributions to the economic and social quality of life by significantly reducing the commute distance and time between the communities of Riverside South and Barrhaven by 12.5 km and approximately 16 minutes. Also, as the Rideau River divides the east and west parts of the City of Ottawa, which are connected by several roadway arterials, the bridge completes the missing link on a new major arterial that cuts the 15km distance between the two adjacent arterials in half. It also provides the missing link between the southwest and southeast transit corridors in the city of Ottawa. Furthermore, the bridge has improved traffic flow throughout the region as well as improved access to commercial, recreational, and cultural facilities on both sides of the river. The bridge opening has promoted further development of the Riverside South Community because of the improved access points. Public safety is also enriched due to the enhanced emergency response times as a result of another river crossing point.

On November 8, 2014, at a formal ceremony at the bridge site, the bridge was named the Vimy Memorial Bridge in commemoration of the battle of Vimy Ridge, one of Canada's most significant military achievements. The name stands to honor those who fought, and in many cases gave their lives, at Vimy Ridge. Mayor Jim Watson said at the ceremony, "Vimy Memorial Bridge honours and recognizes our national heritage and one of our greatest military triumphs." With this new name, the bridge, now more than ever, carries forth the national heritage and pride of Canada.

Environmental Benefits *Explain how your project addresses environmental/sustainability issues.*

Reducing the commute time and distance between the two urban communities joined by this bridge results in significant transportation energy savings for commuters and others, and contributes in a small but positive way to the reduction of greenhouse gas emissions. Also, it significantly reduced traffic on the adjacent most nearby river crossing that is located in the small town of Manotick, thus enhancing the quality of life there.

The Rideau River forms the historically significant and protected waterway of the Rideau Canal. It is home to various wildlife species and is a recreational waterway used extensively by the general public during the summer months. For these reasons, it was very important to minimize bridge construction impacts on both the water habitat and the recreational users. The majority of the bridge superstructure (80%) was constructed on land at the east approach and then launched into position over the waterway during a two-day period. This enabled the waterway channel to remain open throughout construction, minimizing the impact on recreational river users as well as minimizing the environmental impact on the surrounding area, particularly in ecologically sensitive regions.

The bridge design incorporated several sustainable and durability features to achieve a 100-year service life and to minimize future works to the bridge. This was achieved by a combination of durable material selection, proper detailing, ease of maintenance, and detailed quality control. One of the more important design features that improves durability is the selection of closed members. The three freestanding overhead arches are made of tubular pipe members completely sealed to the elements. The closed section philosophy was extended to the main load-carrying floorbeams of the steel deck grillage system, which are comprised of closed welded box sections sealed to the environment in order to optimize durability and minimize corrosion. Other sustainable design features include:

- The bridge is built with materials that have reduced corrosion potential and that resist degradation processes. These include galvanized rebar in the deck and painted atmospheric corrosion-resisting (weathering) steel for the deck grillage. In addition, the arches are painted with a four-coat system to extend the service life.

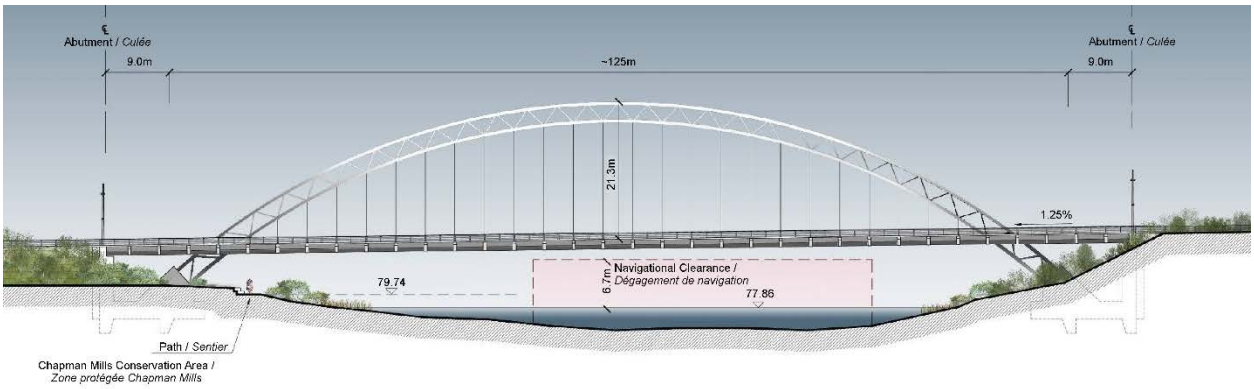
- The hanger system connecting the deck to the overhead arches is comprised of multi-strand cables having triple corrosion resistance protection. The hangers are equipped with anchorage nuts that allow easy adjustment and replacement of individual hangers.
- LED light fixtures significantly reduce energy consumption and last longer than any comparable lighting system.

Meeting Client's Needs *Explain the client's main project goals and how you met them.*

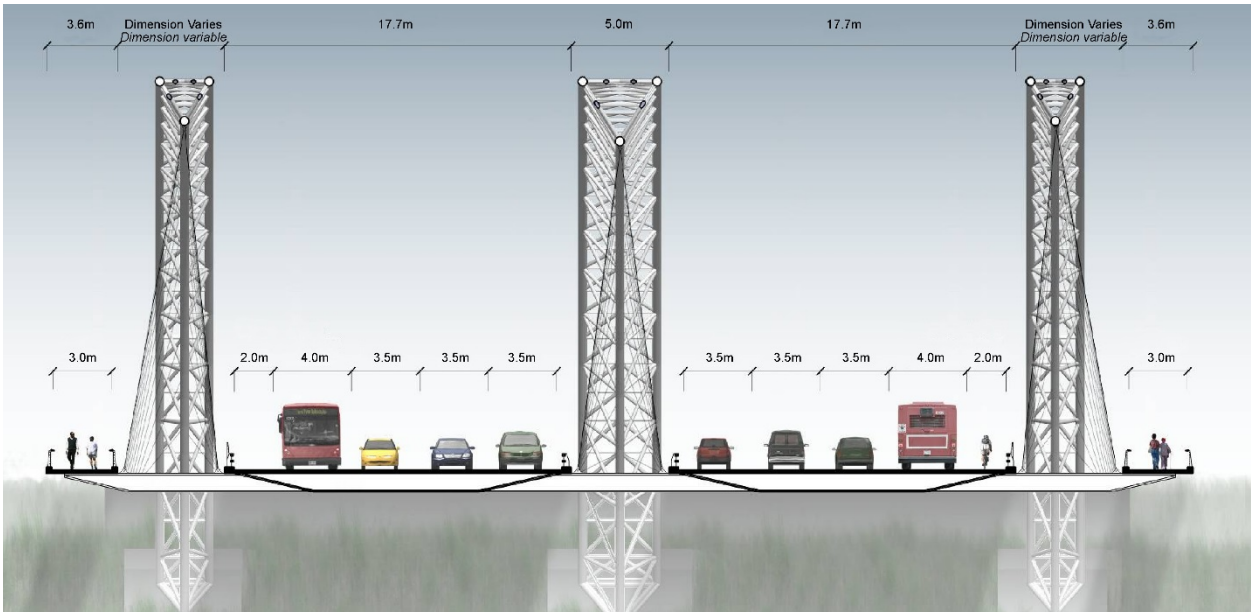
The ultimate client for the engineering design team on this project was the City of Ottawa and its citizens. The design team exceeded the client's expectations by creating a gateway structure that addressed the disparate requirements of accommodating a very wide deck and the need to develop a light, airy, and transparent structure while limiting the impact to the historical waterway below the bridge. The engineering services for this project have been completed to the client's satisfaction and the overall project objectives have been met within the approved timeframe and budget. The bid price of the project was within 1% of the engineer's estimate.

"It looks like our version of the Eiffel Tower right here in Riverside South. This is going to be a new landmark. Forget the Sydney Opera house, forget the bridge in St. Louis. We've got the Strandherd Armstrong Bridge," said Jim Watson, the current City of Ottawa Mayor, at the grand opening ceremony of the Vimy Memorial Bridge (formerly Strandherd-Armstrong Bridge) on July 12, 2014.

Bridge Plan



Bridge Elevation



Bridge Cross-Section

Figure 1: Overview of the Vimy Memorial Bridge

Figure 2: The Vimy Memorial Bridge crossing the Rideau River

Figure 3: Exterior arch springing through the opening between the vehicular deck and the pedestrian walkway

Figure 4: Structural steel grillage system supporting the vehicular deck and the pedestrian walkway with slots for permitting light to penetrate through the deck

Figure 5: The floor beams supporting the sidewalk were tapered under the sidewalk resulting in an aesthetically pleasing fascia

Figure 6: Steel arches with elegant tubular welded connections

Figure 7: Hanger system suspending the deck from the arches

Figure 8: The bridge accommodates a pedestrian walkway, cyclist lanes, a bus lane, and a left turn lane in each direction