STRUCTURAL DESIGN INNOVATION

FAIRWAY ROAD GRAND RIVER BRIDGE

Cast-In-Place Concrete

PROJECT CREDITS

OWNER
Region of Waterloo

ARCHITECT OF RECORD
DTAH Architects Limited

ENGINEER OF RECORD
MMM Group Limited

GENERAL CONTRACTOR
Grascan Construction Ltd.

BRIDGE CONSTRUCTION SUB-CONTRACTOR
Torbridge Construction Ltd.

FORMWORK SUPPLIER
Aluma Systems Inc.

MATERIAL SUPPLIER
Dufferin Concrete, A division of Holcim (Canada) Inc.

ADDITIONAL PARTICIPANTS
- Euclid Canada
- Freyssinet Inc.
- Gilbert Steel Ltd.
- Ironworkers Local 736
- LIUNA Local 1081

PROJECT FACTS

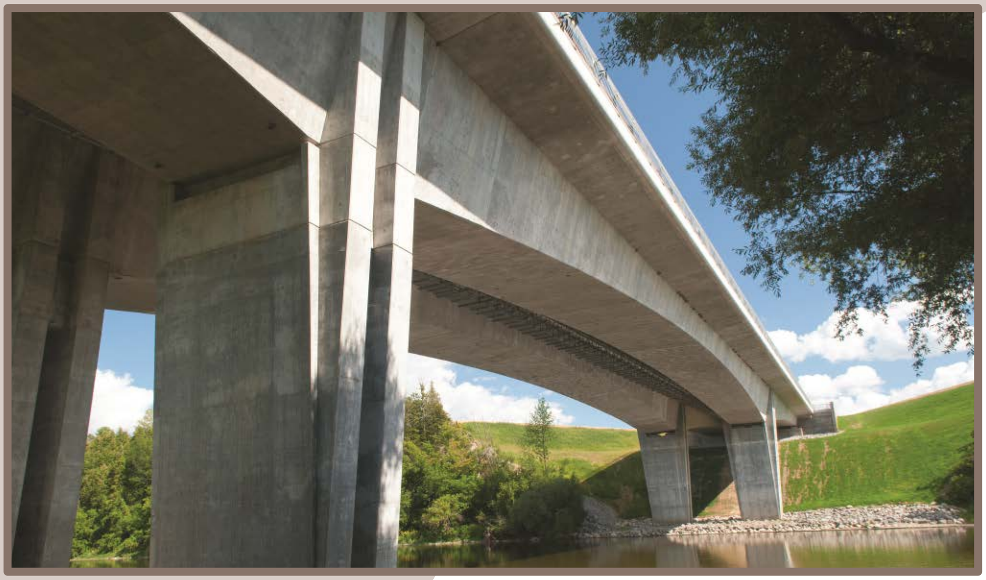
LOCATION Kitchener/Cambridge, Ontario

COMPLETION June, 2013

TONNAGE
- 23,300 t

QUICK PROJECT FACTS
- Length – 237 m
- Width – 25.85 m
- Span Length – 237 m
- Main Span – 95 m over the river

2013 Ontario Concrete Awards



Project Overview

The Fairway Road Grand River Bridge in the Region of Waterloo, Ontario, is a twin four-span, high-level, variable-depth, post-tensioned, cast-in-place, twin-box-girder segmental bridge that reaches 237 m in length with a main span of 95 m. The bridge carries four lanes of traffic with multi-use sidewalks for pedestrians and cyclists on both sides and provides an alternative link between the City of Cambridge and the City of Kitchener. This bridge represents the first new bridge constructed over the Grand River in the area in more than 40 years.

During preliminary design, several alternative structure types were considered with the preferred method being a variable-depth concrete-box-girder bridge that spans the river with no piers in the water. Architectural enhancements including tapered piers, accent lighting, and specially designed pedestrian railings add to the aesthetic quality of the bridge. A special concrete mix design was also specified to provide a 100 year design life.

The bridge was designed and constructed using over 23,000 tonnes of concrete constructed using segmental construction techniques to avoid the need for piers and temporary supports in the water to accommodate environmental and First Nations considerations. The three-approach spans were constructed on falsework and the main span over the Grand River was constructed using segmental cantilever construction techniques. The bridge was analyzed using the construction staging functionality in MIDAS Civil and designed in accordance with CAN/CSA-S6-06 and the AASHTO Guide Specifications for Design and Construction of Segmental Concrete Bridges. The superstructure is integral, with the centre pier and supported on spherical bearings at the north and south piers to accommodate thermal movements and to avoid locked-in stresses in the piers resulting from the construction of the approach spans on falsework.

Construction of the bridge was completed between October 2010 and November 2013. The construction of the span over the river was completed using two-form travellers, advancing from the centre and south piers, and meeting in the middle.

Architectural Merit

Given the prominence of the bridge in the area and the large number of people using this bridge on a daily basis, creating a structure of architectural merit was important to the Region of Waterloo. Therefore, during the Class EA study, the aesthetic quality of the bridge crossing was identified as an issue of public interest. The architectural enhancements included tapered piers, accent lighting, specially designed pedestrian railings, City gateway markers, custom 'wave' railings, natural stonework, pedestrian lookout plazas, and enhanced pedestrian and cycling facilities.

Also, the Grand River is recognized as having a number of features / functions including a Canadian Heritage River designation, a warm water sport fishery, areas with steep valley slopes, waterfowl staging, migratory birds, and resident wildlife habitat. The bridge provides pedestrians, cyclists and motorists with far-ranging views of the Grand River Valley.

Creativity

The challenge for the design team was to enhance the architectural beauty of the crossing while minimizing

material use and cost and creating a safe and highly functional river crossing. Meeting these goals required creative, outside-the-box thinking.

A significant example of this creativity is the use of a long span design to allow for a clear crossing without piers in the river. Avoiding in-water work was one of the key commitments made to local First Nations community. This was also important to minimize impacts to marine habitat including warm-water sport fish and three Species At Risk, minimizing potential for ice jamming and simplifying construction.

To accomplish this, the design features twin, single-cell box girders, each with a deck width of 12.9 m, including 2.5 m cantilevers on each side. This is a large deck width for a single cell box girder and required transverse post-tensioning along the full length of the deck to support the long deck cantilevers. The spans are 37.0 m, 65.0 m, 95.0 m, and 50.0 m.

The main span over the river is comprised of 19 cast-in-place box girder segments constructed using form travelers. Each segment is 4.75 m in length and varies in depth from 5.2 m at the piers to 2.4 m at mid-span.

Quality of Engineering Design

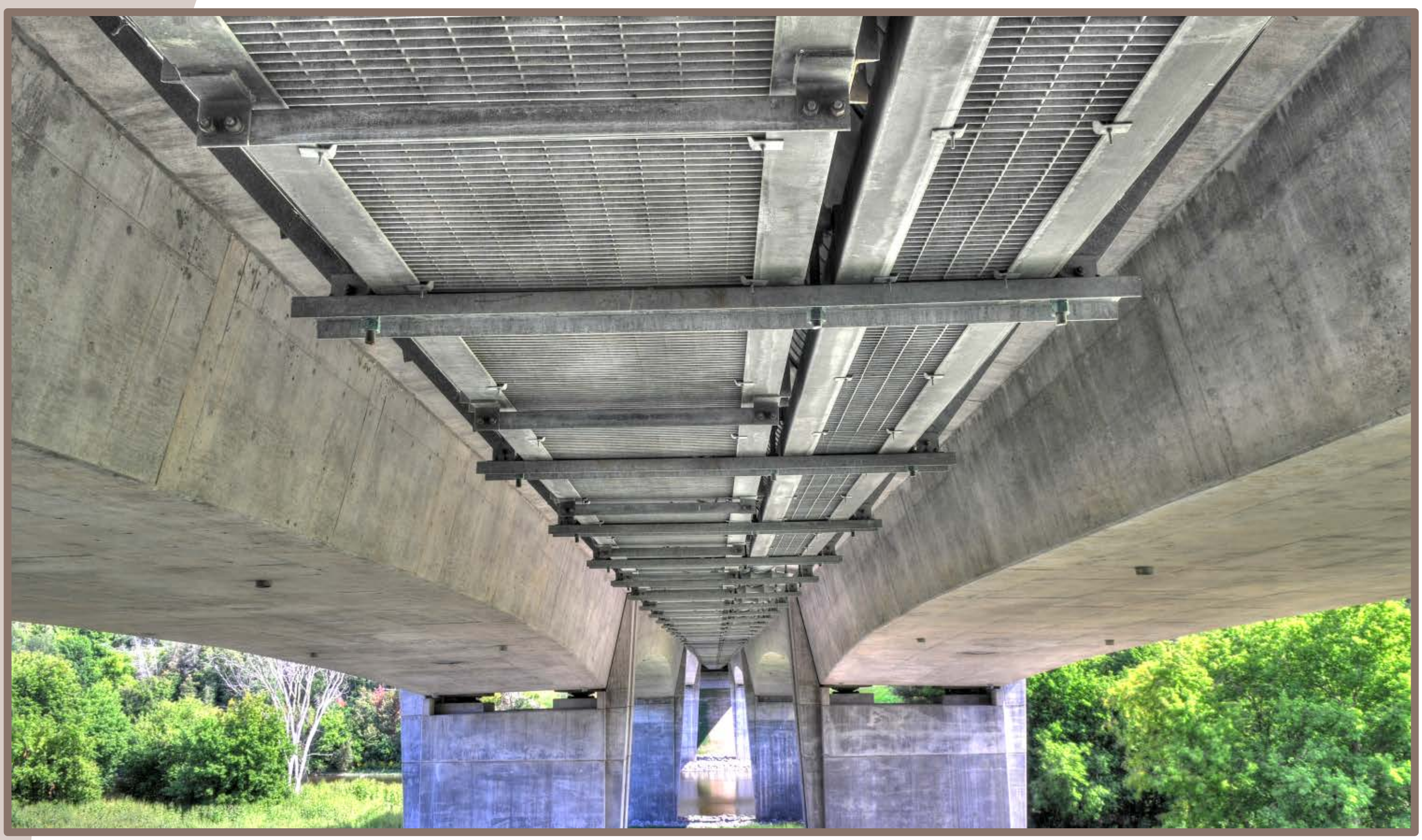
Longevity and minimized maintenance were key goals for the bridge design from the client's perspective. Thus, a performance-based concrete mix design was specified to achieve a 100 year service life. Additionally, the concrete mix had a maximum water to cement ratio of 0.34, a maximum chloride diffusivity of 5x10-13 m^2/sec, a maximum air void spacing factor of 220 µm, and a minimum compressive strength of 50 MPa at 28 days.

To reduce the potential for cracking due to seasonal contraction and expansion, the bridge's box girders are post-tensioned both longitudinally and transversely so the superstructure is always under compressive stress.

Innovative Construction Techniques or Solutions

The main span of the Fairway Road Grand River Bridge was designed as a cantilever segmental structure to avoid the need for any in-water piers or temporary supports. The three-approach spans were constructed on falsework.

Segmental construction has not been used in Ontario for two decades. 4.75 m long segments were sequentially cast using form travellers working outwards from the piers at each edge of the river. Each segment was post-tensioned back into the previously completed portion of the structure before advancing the form traveller for the next segment. Segments were generally constructed on a seven-day casting cycle.



Tight tolerances were specified for the construction of the segments over the river. A geometry control program was developed, including a geometry control manual that specified formwork elevations for the segmental span and for the spans cast on falsework. The geometry control manual also included requirements for geometric monitoring during all stages of construction to capture time dependant effects such as thermal expansion/contraction, creep, and shrinkage.

The formwork elevations were then adjusted as required during construction to ensure the two cantilevers met at the required elevation and alignment at mid-span. The north and south cantilevers leading up to the closure span for the segmental span of each bridge met within 12 mm, indicating a high level of accuracy.

The contractor implemented cold weather work plans to successfully work through two winters. The contractor followed the requirements in the Ontario Provincial Standard Specifications for a temperature control plan which defines the responsibilities of the contractor for cold weather protection during concrete placement and curing. This included monitoring temperatures at multiple locations within the structure using internal thermocouples. Temporary protection of stressed, ungrouted post-tensioning tendons over the winter was provided by injection of a corrosion inhibiting powder. The powder coated the strands and provided temporary protection for the tendons until temperatures were warm enough for grouting.

Complexity

The bridge is approximately 20 m above the river and crosses a flood plain on the north side of the river to a steep slope on the south. At this location, the river is approximately 80 m wide. It is the largest bridge of its kind over the Grand River (95 metre main span, 247 metre overall length).

While box girder bridges are fairly common, segmental construction is rarely used in Ontario. The Fairway Road Grand River Bridge is only the 8th concrete segmental bridge constructed in Ontario and the first one in 20 years. Complex analysis was required during detailed design to completely model the construction staging and time-dependent effects of creep and shrinkage inherent in this type of construction. The box girder was constructed at variable depths with inclined webs with complex design, geometry, and pleasing aesthetics.

Functionality and End-Use Suitability

Ultimately, the success of this bridge project rested on achieving a functional bridge for pedestrians, cyclists, and motorists. The bridge carries four lanes of traffic with multi- use sidewalks for pedestrians and cyclists on both sides. There are also look-outs provided on the bridge to allow pedestrians and cyclists to pause to enjoy the vista.

By providing a transportation route used by 7,500 cars per day, the bridge provides much needed relief for the congestion on King Street and Highway 8 across the Grand River, shortens the travel distance between Kitchener and northwest Cambridge, and contributes to accommodating travel demand that will be generated by growth and land development in the Region.

The project finished on time and on budget with significant positive feedback from both the client and the public.