PORT MANN BRIDGE/HIGHWAY 1 IMPROVEMENTS *Vancouver, BC*

Contract Value: C$2.69 billion

Client: Transportation Investment Corporation

Contract Type: Design-Build

Completed: November 2014

Key Team Members:
Scott Hoodenpyle, James Scheer, John Lozner, Fritz Lausier, Bryan Lechner

Award Sampling:
2016 Engineering Excellence in Transportation and Bridges Award, Piece-by-Piece Demolition, American Council of Engineering Companies–British Columbia

2014 Award of Excellence, Transportation Category, Canadian Consulting Engineering Awards

2013 Contractor of the Year, Bridges and Structures, Deputy Minister for Transportation and Infrastructure

Kiewit led the joint-venture partnership for the largest transportation infrastructure project in British Columbia's history. The corridor is the most heavily traveled in the Vancouver area, and the bridge carries more than 250,000 motorists every day. Replacing the bridge and widening the highway corridor improved access and safety for approximately 23 miles.

The project's signature feature is the new, 10-lane cable-stayed Port Mann Bridge over the Fraser River. The 1.25-mile-long bridge's record-setting 1,540-ft.-long main span is supported on two 520-ft.-tall center pylons. Like the Ship Channel Bridge, the Port Mann Bridge crosses over a vital commercial shipping waterway and multiple rail lines in a busy industrial area.

The Port Mann Bridge shares several key characteristics with the Ship Channel Bridge:

- iconic long-span, cable-stayed bridge
- construction on an existing alignment alongside an existing, heavily trafficked bridge, using two-phase construction
- erection of transportation infrastructure on soft, highly compressible soils
- marine traffic management for a commercial shipping channel
- extensive utility protection and relocation requiring coordination with multiple utilities
- installation of tolling and intelligent transportation technology support (ITS) infrastructure
- sequenced demolition and removal of a large bridge with in-water piers

The construction and demolition methods for this award-winning project are similar to those we will use for the Ship Channel Bridge. Despite the challenging complexities of this mega–design-build project, the principal contributors we are proposing for the Ship Channel Bridge planned, coordinated, and completed Port Mann Bridge well ahead of the original schedule.

> ***This is a large, complex project that includes construction of a major cable-stayed bridge, in fact the widest in the world....all while maintaining traffic on the busiest corridor in the province. Kiewit has been uncompromising in maintaining a solid safety program. This recognition of maintaining a safe environment extends to ensuring construction work retains a safe roadway for vehicles at all times.***
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> **—Garry Dawson, Project Manager, Port Mann Bridge, Transportation Investment Corporation**

RAPID CONSTRUCTION FOR EARLY COMPLETION

Kiewit used phased construction and multiple fast-track strategies to deliver eight of the ten lanes nearly one year ahead of schedule, meeting the deadline for early tolling. In fact, the project team accomplished an average of $1.2 million of work for each of the 2,281 calendar days as compared to the anticipated $258 thousand for the Ship Channel Bridge.

We constructed the project in two phases. First, we constructed eight lanes of the bridge and approaches and opened the newly constructed portion of the bridge to traffic; we completed the remaining two lanes during the second phase. This permitted the client to begin tolling on the new bridge while construction was still underway.

Fast-track strategies that supported early completion included using an off-site precast and fabrication yard, which allowed the team to build and stockpile precast segments before they were needed. The segments were then supported on purpose-built segment lifters and transported from the precast yard to the site via barge. This shortened each 14-day cycle by two days, reducing the critical path by a total of 30 days.

To further accelerate the schedule at Port Mann Bridge, the team slip-formed the pylons, which allowed crews to advance the form system over the 240-ft.-high mid-pylon portion in one continuous operation. The slip-form climbed at a rate of just over 13 ft. per day, reducing pylon operations by 50 days.

MINIMIZING IMPACTS TO MARINE TRAFFIC

Fostering open relationships with the port stakeholders allowed us to plan and communicate information in advance, reducing impacts to the shipping channel. Scott Hoodenpyle's team created and chaired the Port Mann Marine Communications Group (PMMCG), which facilitated the exchange of information between construction management and commercial marine users. The PMMCG met monthly during the early stages of construction and proved to be highly effective; Kiewit worked with commercial marine companies to prevent interruptions to marine traffic while advancing construction operations. A similar group communicated and coordinated with local First Nations tribes to avoid impacting their fishing activities.

MAXIMIZING PRODUCTION WITH MOCK-UPS

While planning the pylon work, Kiewit used mock-ups to organize construction and sequencing, increase productivity learning curves, and identify and resolve design conflicts off the critical path.

The team, led by James Sheer our proposed pylon manager for the Ship Channel Bridge, built full-size replicas of the anchor boxes, located in the upper pylon, where the cable stays connect (**Figure 14**). These mock-ups allowed us to determine the ideal method for installing reinforcing steel and maximize the amount of reinforcing steel that could be pre-installed on the ground, off the critical path.

Figure 14: Building full-sized replicas of the anchor boxes allowed the pylon team to improve construction methods off the critical path.

Based on what we learned from the mock-ups, we made minor design changes to eliminate conflicts. We determined that prefabricating two anchor boxes on the ground would allow us to install the rebar between them before lifting them into place on the pylon. The mock-ups also confirmed that our selected cable installation tools would correctly fit in the tight spaces.

We also built partial pylon mock-ups to work through slip-forming procedures. This improved the production learning curve off the critical path.

DEDICATED THIRD-PARTY COORDINATION

The project traversed five municipalities—affecting numerous communities, stakeholders, interest groups, and other third parties. Collaboration with the client and those affected by the project was integral to the progress and success.

Kiewit's single point-of-contact for third parties worked extensively with the client, holding daily coordination meetings to communicate potential traffic and access conflicts.

We also took the initiative to engage third parties early and to develop relationships and cooperative approaches to address mutually challenging construction-related issues. The team also enlisted the help of local fire departments to develop rescue plans that met the Canadian Coast Guard's requirements.

Public communication efforts included creating a website, sending emails, making public announcements, and attending town hall meetings. Throughout construction, Kiewit supported these communication strategies, particularly with regard to vehicle and shipping traffic management and major traffic shifts and detours.

Minimizing Impacts to Utilities

A dedicated team coordinated scheduling and engineering and construction activities with 18 utility companies so that we met the overall schedule. Ultimately, the project required more than 190 utility relocations. By working collaboratively with utility providers, Kiewit was able to assess conflicts between existing utilities and proposed work in a timely manner.

We also developed numerous utility protection plans to address a wide variety of challenging conditions, including construction access for crane and heavy vehicle crossings (**Figure 15**). Soft ground conditions posed an added challenge that was addressed in the protection plans.

Figure 15: Tight right-of-way access and soft soils along with numerous utilities at the approaches challenged the team to develop a comprehensive approach to the work and coordination effort.

Minimizing Impacts to Rail

Goods with a value of approximately 14% of Canada's gross national product travel under the bridge on a huge network of Canadian National Railway Company (CN) rail lines (**Figure 16**). Mitigating impacts to their operations was critical to managing this project.

Figure 16: By coordinating with CN rail, James Scheer protected their operations during main span construction directly over numerous rail lines.

James Scheer began communicating with CN early and continued to foster the relationship throughout the project.

Three months before bridge construction began, James reached out to CN, setting up meetings to explain our work and schedule. Follow-on meetings were then held regularly to discuss both long- and short-term schedules. At the beginning of the project, CN established maximum durations of allowable closures that were limited to 15 minutes, with closure requests submitted days in advance.

CN maintained ultimate control of their schedule at all times; Kiewit managed and planned around their needs. However, as CN developed trust in our ability to follow through as planned, longer closures were permitted whenever feasible.

As the project transitioned to the demolition phase, James transferred his operational knowledge and connections to Fritz Lausier. During this transition, James and Fritz both attended meetings with CN until Fritz became their main point-of-contact.

The strong relationship we forged with CN resulted in cost and schedule benefits.

- Flaggers were posted at all times during construction as required. These CN workers were restricted to limited schedules; however CN informed us that retired rail workers were looking for shifts as flaggers. Because the retirees could work non-traditional hours, this translated into a more flexible schedule for our work and saved on overtime costs.
- When it was time to install tie-downs—cables tied to the footings and concrete blocks on the ground to prevent the unjoined bridge from shifting in the wind—CN notified us of a two-day period when rail traffic would be diverted away from the work area. This gave us full access to complete tie-down installation unimpeded by rail interruptions.

- The railroad permits required annual renewal and CN approved each application without issue, as we had proven our ability to work without harming the tracks or undue disruption to their operations.

James' team took all necessary precautions when working near rail during construction. Fritz's team provided protection, including netting, over the railway before demolition to keep rail lines safe during overhead work. Crews coordinated with railway personnel when working overhead, and spotters were on site as necessary. Workers used tool lanyards to prevent dropped tools. Hot work permits and fire watches, with careful attention to the creosote rail ties, were strictly enforced.

MAXIMIZING PREFABRICATION

Kiewit focused on opportunities to reduce critical path durations by precasting concrete elements and prefabricating as much as possible. The team self-performed precasting and stockpiled the segments.

The schedule milestones were included in the linear schedule to determine the necessary number of precast beds and production rates. We analyzed the most cost-effective solutions and selected a highly qualified local concrete supplier. We set up three precast beds for typical sections and two beds for special sections (**Figure 17**). The segment precast yard was situated on the river for easy water transportation.

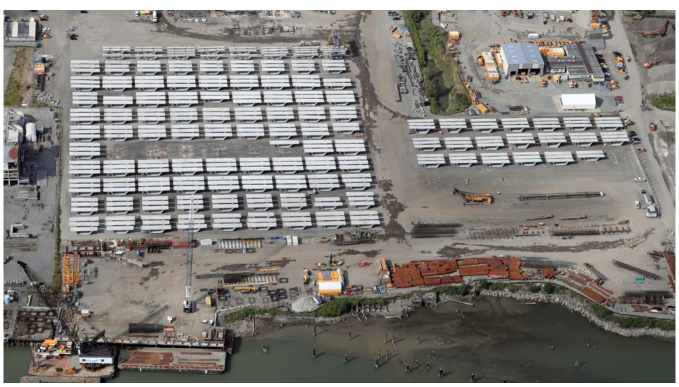

Figure 17: Match-casting the Port Mann Bridge segments at the off-site precast yard ensured strict geometry control, as it will at the Ship Channel Bridge.

SEGMENTAL ERECTION

Kiewit erected the precast segments with a purpose-built self-launching gantry crane, using two different methods. The first method, span-by-span, used at the long approach structures typically erected 14 segments that were tensioned together to become 150-ft. spans. We also used the balanced cantilever method to construct the over-water main span and the longer, 300-ft.-long spans over commercial buildings on the north end of the bridge. Where buildings at the site hindered delivery by water, we fed the segments from land using job-engineered delivery trucks (**Figure 18**).

Figure 18: Used both the balanced cantilever and span-by-span approach to build the Port Mann Bridge and its approaches: A span-by-span erection of precast segments at the approaches; B balanced cantilever erection of precast segments at long spans over active businesses; and C concurrent pylon construction and balanced cantilever erection using segment lifting devices.

SAFE AND CONTROLLED DEMOLITION

Safely releasing the counter-balancing forces during controlled demolition is every bit as challenging as construction. Fritz Lausier spent one year leading planning and preparation for demolition of the existing 6,900-ft.-long steel truss bridge. The team, including Bryan Lechner, Kiewit's lead demolition engineer, examined the original blueprints from the 1960s to learn how the trusses' arches were supported and retrace the original builder's steps during the demolition. As a result, the main span, approaches, and foundations were removed in a safe and controlled manner, without incident.

"The first thing that was evident was that Kiewit understood the issues at hand both on the demolition front as well as the environmental impacts that may arise from it."

—Garry Dawson, Project Manager, Port Mann Bridge, Transportation Investment Corp.

Site preparations included building a temporary trestle for improved work access and dredging to allow marine equipment access.

Kiewit self-performed the demolition of the 1,970-ft.-long main span and the approaches, which had 3,280 ft. over land and 1,640 ft. over water. Deck demolition included saw cutting and wire cutting concrete over the waterway, during which crews fully contained debris and slurry. Fritz's team also demolished concrete piers, pedestals, and foundations.

Kiewit supported the bridge throughout demolition so that no unplanned movements occurred. We installed temporary bracing in the tower arches of each side span. Longitudinal braces were hoisted over the side by two cranes on the deck, positioned with offset spreader beams, and welded into place (**Figure 19**).

Figure 19: Bryan Lechner, lead engineer, designed temporary bracing and stay cables to support the old bridge during deconstruction.

Once the bracing was complete, the team erected temporary stay towers. Temporary stay cables supported the center span arch and back span deck. With the stays fully stressed, the bridge was ready for disassembly. Crews cut the center girders, slowly released the hydraulic rams, and eased tension across the cut. An 8-in. gap opened between the two sides, leaving two stable, independent structures ready for deconstruction.

We then removed each member piece by piece (**Figure 20**), and the majority of materials were subsequently recycled. Crews relocated cable stays as work proceeded.

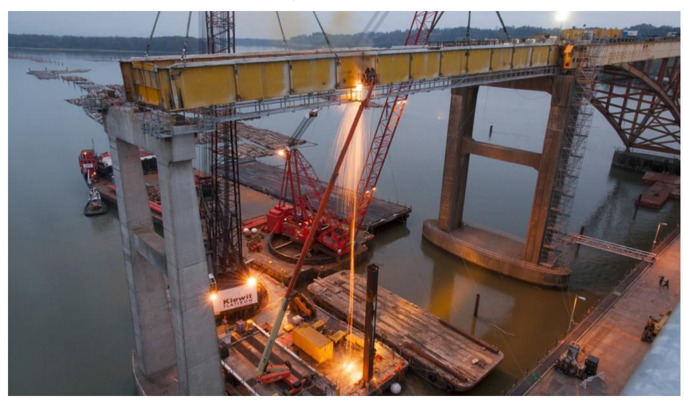

Figure 20: Girders on the bridge approaches were cut into sections with thermal lances. Cranes supported the girders and lowered them onto barges.