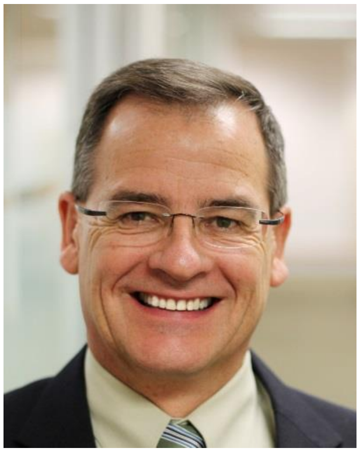
REPLACING SASKATOON'S HISTORIC PARKER TRUSS "TRAFFIC BRIDGE"



MURRAY JOHNSON, PE

BIOGRAPHY

Murray Johnson P.Eng., P.E. is a Vice President and Project Director with COWI Bridge North America, based in the Vancouver, BC, Canada office. He was the design lead for the replacement Traffic Bridge during the P3 pre-bid design, then became the Project Director for the design of both bridges in the North Commuter Parkway and Traffic Bridge project when the Graham Construction team was awarded the project.

Murray has been involved with the design, construction, inspection, repair, assessment, and rehabilitation of bridges of almost all types throughout his 38 year engineering career. 25 years of this career has been spent with COWI Bridge North America (formerly Buckland & Taylor Ltd.).

SUMMARY

The Traffic Bridge in Saskatoon, Saskatchewan, Canada was opened in 1907 as five spans of riveted steel Parker trusses with a timber deck, on concrete piers and abutments. It was Saskatoon's first vehicular crossing of the South Saskatchewan River. After more than 100 years of service, the bridge was closed permanently in 2010, due to structural safety concerns. In 2014 the City of Saskatoon initiated replacement of the bridge as part of a P3 project that also included building the separate North Commuter Parkway and Parkway Bridge, and in 2015 the City awarded a contract to Graham Commuter Partners for design, construction, financing, operation, and maintenance of the project.

The RFP for the replacement bridge required that the new bridge be very similar in form and appearance to the original, of steel Parker trusses, with rehabilitation of the in-river piers and a Service Life of 100 years. The project was won by the Design-Build team by optimizing the reference concept and developing innovative ways to construct the bridge.

The new trusses are designed with primarily rolled sections and fully bolted connections, with the fabricator collaborating in design of details. Deck and sidewalks employed precast panels to speed construction, save cost, and ensure quality. The end result meets the requirements of the RFP while providing a competitive design.

Replacing Saskatoon's Historic Parker Truss "Traffic Bridge"

Introduction

The Traffic Bridge in Saskatoon, Saskatchewan, Canada was opened in 1907 as five spans of steel Parker trusses with a timber deck, on concrete piers and abutments. With a total length of 961 ft, It was Saskatoon's first vehicular crossing of the South Saskatchewan River. After more than 100 years of service, the bridge was closed permanently in 2010, due to structural safety concerns. In 2014 the City of Saskatoon initiated replacement of the bridge as part of a P3 project that also included building the separate North Commuter Parkway and Parkway Bridge, and in 2015 the City awarded a contract to Graham Commuter Partners for design, construction, financing, operation, and maintenance of the project. The new bridge is scheduled to be opened in October of 2018.

Location

The City of Saskatoon is located in the southern portion of the Province of Saskatchewan, Canada, see Figure 1. With an approximate population of 300,000 people, it is Saskatchewan's largest urban center. Straddling the South Saskatchewan River and connected by a major highway, two railroads, and an international airport, the city is a major transportation and economic hub for the Canadian Prairies.

Figure 1- Location of Saskatoon

The Traffic Bridge crosses the South Saskatchewan River in the heart of the downtown core, on a bend in the river between two other roadway bridges, see Figure 2.

Figure 2 – Location of Traffic Bridge

Original Traffic Bridge

In 1905, there were three separate communities on this bend in the South Saskatchewan, the Villages of Saskatoon, Nutana, and Riversdale. Occupying both banks of the river, they were only connected by a somewhat unreliable seasonal ferry service and a nearby railway bridge, which was dangerous to walk across. When it was proposed that they merge to become the City of Saskatoon, it was deemed necessary to connect them with a permanent vehicle bridge. When Saskatchewan became a Province in 1905, the first sitting of the legislature included approval of the funding to build the Traffic Bridge.

The bridge was designed by the provincial Department of Public Works and constructed by John D Gunn and Sons of Winnipeg Manitoba. The superstructure steel was fabricated by the Canadian Bridge Company of Walkerville (now Windsor) Ontario and erected by the McDiarmid Company of Winnipeg. In addition to its significance as Saskatoon's first vehicular bridge, it had engineering significance in being the first large steel bridge in Saskatchewan to be built on concrete foundations, and its concrete was the first to be subjected to a formal quality control procedure.

Construction began in August of 1906 and the piers were completed late that year, however steel delivery delays, along with having to wait until the spring breakup in 1907 in order to erect falsework, meant that steel erection was not started until June 1907. This was completed and the floor installed by October 1907 and the bridge opened to the public in that month.

The original bridge had five spans of riveted steel Parker trusses. The two end spans had seven panels each with a span length of 175 ft, while the three central spans had eight panels each with span lengths of 200 ft. The roadway width was a total of 19.5 ft, and comprised a timber deck, later overlaid with asphalt. See Figure 3 for the original appearance.

The bridge's steel Parker trusses were fabricated in the usual manner of the day, built up from angle and channel sections and plate riveted together into truss members with battens and lacing bars.

The bridge was first constructed without a sidewalk but it was quickly realized that one was needed, and a 6 ft wide sidewalk was installed on brackets added to one side of the bridge in 1908.

In June of 1908, a steamship, the City of Medicine Hat, struck the southernmost river pier, capsized, and sunk. No lives were lost, but this became significant over 100 years later during design of the new bridge as the wreck was deemed an archeological site.

Figure 3 – Traffic Bridge as it Appeared When New

The original Traffic Bridge served well for over 100 years, with some rehabilitation work and with posting for limited loads, however in August of 2010 it was permanently closed due to safety concerns. Deterioration, primarily corrosion of steel elements in the lower regions of the bridge – the "splash zone" where dirt, water, and salt take a greater toll on the steel – had reached the point where it was no longer practical to maintain the bridge with any load-carrying capacity.

After closing, and prior to the commencement of the procurement for the replacement bridge, the southernmost span of the bridge was demolished. When first built, this span was over water, however over the years the land had been filled in beneath it to the point where the entire span was over land. Included was a roadway passing under the span as well as walking paths, so the span was removed to mitigate concerns about collapse. In Figure 4, this span would have been in the lower right-hand corner of the photo. Figure 5 shows the resulting end of the old bridge, as it appeared at the start of the current project. It is this pier against which the City of Medicine Hat was wrecked and which became a protected archeological site.

Figure 4 – Traffic Bridge in 2015

Figure 5 – In 2015, with South Span Demolished

North Commuter Parkway and Traffic Bridge P3 Project

Following closure of the original Traffic Bridge, the City of Saskatoon became a study and public involvement process to determine what to do with the bridge. Many alternatives and ideas were considered, at the end of which a decision was made to replace the bridge with a modern truss design, having a similar appearance to the original. The new bridge would have two traffic lanes of 12 ft width within the trusses, plus two multi-use paths of 10 ft width outside the trusses. This new bridge will restore the roadway link lost when the old bridge was closed, and will in fact enhance it, as emergency vehicles will now be able to cross where before they could previously not due to load limits and height restrictions (see Figure 6). As well, the new bridge will provide much improved pedestrian and cyclist links across the river in the heart of downtown and is expected to increase the use of these modes and support the growing city center.

Figure 6 – Load and Height Limits on Old Bridge

In 2013, the City decided to combine the Traffic Bridge replacement project with the planned new North Commuter Parkway project, which included another, new, bridge over the South Saskatchewan River further downstream, to take advantage of joint financing and competitive pricing. This combined project would be constructed as a Public-Private Partnership (P3), following a Design-Build-Finance-Operate-Maintain (DBFOM) model with a concession period of 30 years. In 2014 cost-sharing agreements were reached with the Provincial and Federal governments and a Request for Qualifications (RFQ) was issued for interested teams. The project was named the North Commuter Parkway and Traffic Bridge Project (NCPTB).

After the RFQ resulted in a shortlist of three teams, a Request for Proposals (RFP) was issued in December of 2014. For the Traffic Bridge, the RFP required that the new bridge be very similar in form and appearance to the original, of five spans of steel Parker trusses, with rehabilitation and re-use of the in-river piers. Some details were also to be similar in appearance to the existing to enhance the connection to the historical bridge. These included latticed truss members, pedestrian railings of similar appearance to the latticed originals, and concrete sidewalks stamped to have the appearance of timber.

The shortlisted team on which the author is involved comprises Graham Construction as the prime contractor, with ASL Paving as a construction and maintenance partner, and Gracorp Capital and BBGI as financial partners.

COWI Bridge North America (formerly Buckland & Taylor) is the designer for both bridges, Tetra Tech is the roadway and drainage designer, and Clifton Associates is providing geotechnical design. The City has a number of consultants to support them, key among them CIMA+, Stantec, and Associated Engineering.

Bid Design

Many factors come into play when trying to win a bridge Design-Build project, but usually very significant are design and construction innovation and optimization of / improvement upon the Reference Concept. While the Traffic Bridge was just one of three main components of the NCPTB project, reducing the construction, maintenance, and operating cost of it would play its part in winning the job. To this end the bid design team worked on various options to optimize the design and reduce the costs. Some of the ideas that were pursued included an ordinary steel plate girder bridge instead of the trusses, a reduction in the number of truss spans, new foundations instead of rehabilitating the old piers, simplification of details such as latticed web cutouts, and even a plate girder bridge with features added to visually recall the original bridge form. Some of these concepts are shown in Figures 7, 8, 9 and 10.

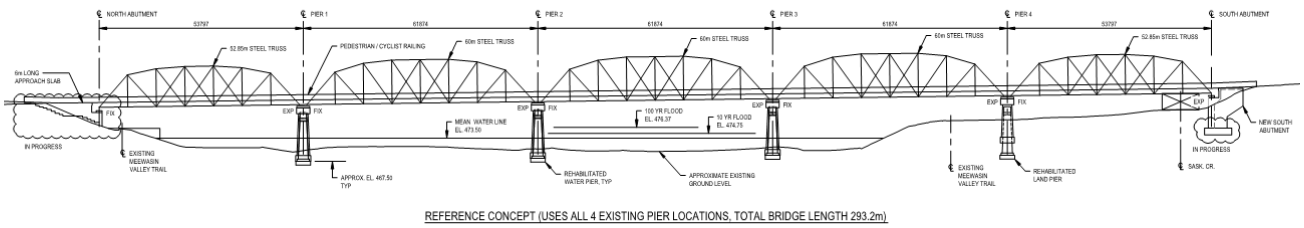


Figure 7 – Reference Concept

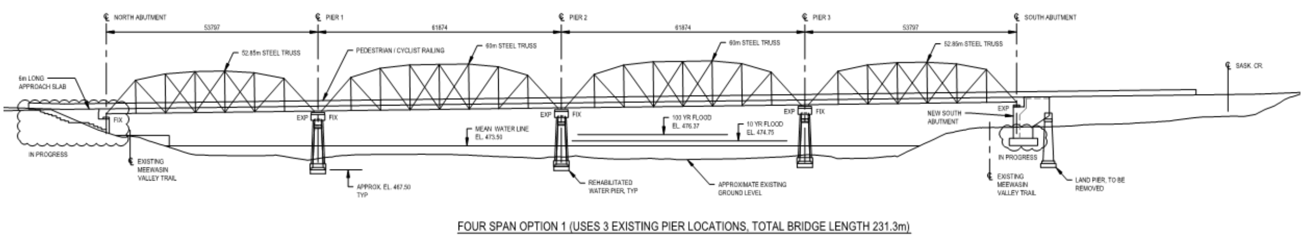


Figure 8 – Four-Span Concept

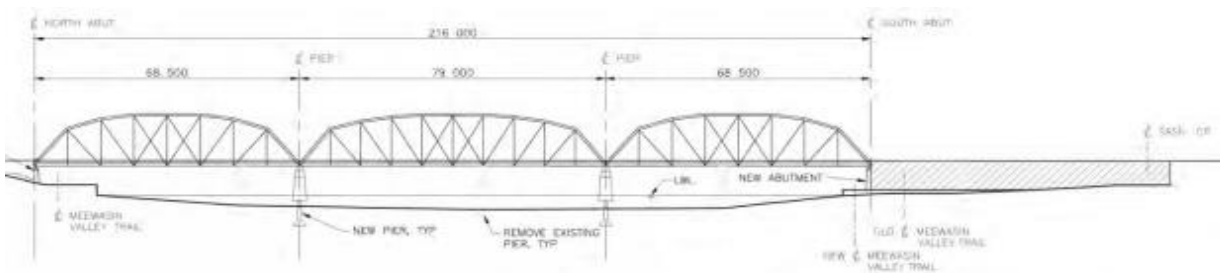


Figure 9 – Three-Span Concept

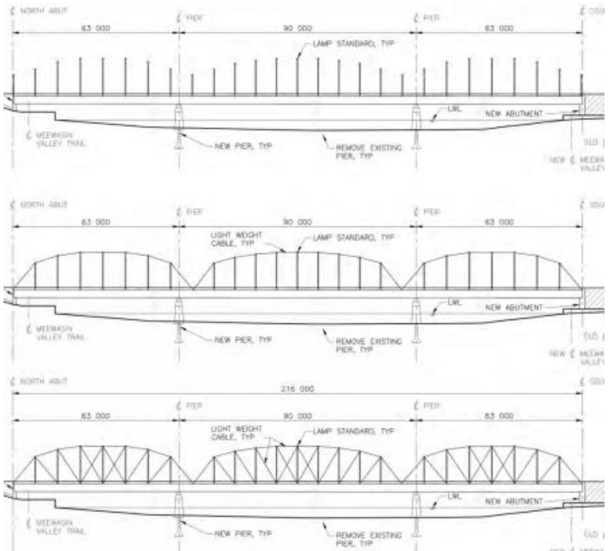


Figure 10 – Plate Girder With Features Concepts

Of course not all concepts generated as potential cost-saving measures would necessarily be acceptable to the City. As for most Design-Build procurements, the process allowed for several meetings with the City and their consultants to present the status of design development and enable commercially confidential enquiries about the acceptability of options. During these meetings, many of the options put forward were not deemed acceptable, as the City was quite determined to have a bridge true to the original form. Two key changes that were accepted included allowing for four new truss spans instead of five, and eliminating the requirement for latticework effects in the truss members.

In the end the option chosen, and accepted by the City, was a four-span truss arrangement (Figure 8) that eliminated the old land span at the south end and replaced it with an embankment and a small overpass structure. The embankment would be landscaped and become a part of the park at that end of the bridge. The truss arrangement was 175 ft – 200 ft – 200 ft – 175 ft, which restored a symmetry to the bridge and enabled the rehabilitation and re-use of the three river piers. The fourth pier, on land, would be demolished and a new south abutment constructed.

In addition to the span optimization, the bid design team developed design and construction innovations for the new bridge. The most significant of these details included a shallow, partially-floating floor system with the concrete deck including partial-depth precast panels under traffic and full-depth precast curb panel units. Another innovation saw the stamped-concrete sidewalks, outboard of the trusses, precast directly onto the steel stringers in the precast plant and erected as entire completed units onto the projecting truss floor beams.

The Graham-led team was successful with their bid, submitted in August of 2015, and a contract was awarded in October of 2015.

Detailed Design

This paper is primarily about the steel bridge superstructure, and will not cover substructures in detail. The design as bid planned to rehabilitate the three river piers, demolish the one land pier, and build two new concrete abutments. The original river piers were founded on spread footings on a very competent glacial till strata. During design it was determined that only a small enlargement of the footings would be required, and a design was developed to encapsulate the old concrete within a new pier shell, see Figure 11.

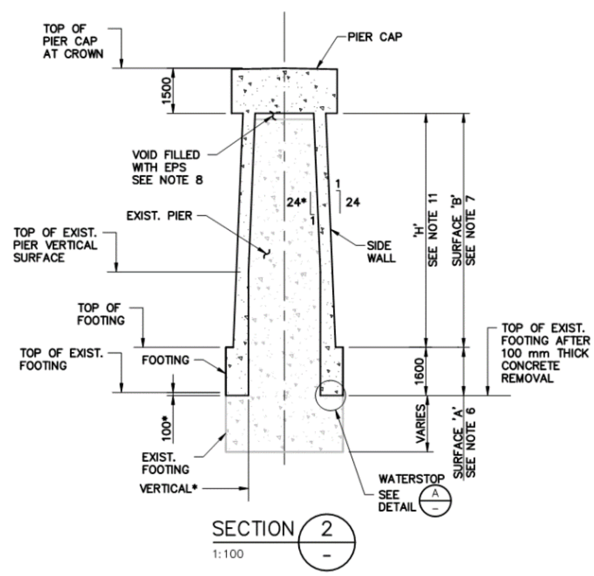


Figure 11 – Rehabilitated Pier Design

This approach was successful, however, upon completion of the first pier rehabilitation during construction, it was decided that the work to prepare existing concrete for re-use was not warranted, and the remaining two piers were re-designed as new concrete founded upon the original footing.

The new trusses are designed with primarily rolled sections, based on W14's, and some built-up sections, using plate gussets and fully bolted connections. The trusses are spaced at 29.5 ft centers, have 25 ft long panels, and have an overall height of 37 ft for the 175 ft spans and 40 ft for the 200 ft spans. This height is considerably more than the original, as full vertical roadway clearance has been provided, but the top chord geometry for the Parker trusses kept the same proportions as the original trusses to provide a similar appearance. The diagonals are arranged in the classic Parker orientation, tension-only, with counter-diagonals in the middle two or three bays. Typical truss configuration is shown in Figure 12.

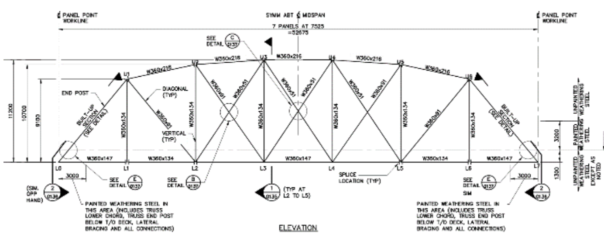


Figure 12 – New Truss Configuration

There are top and bottom lateral bracing systems comprised of 8 in angles in a tension-only configuration. Sway bracing between the upper portions of vertical members has been intentionally made up of light angles to recall the original steelwork, while the portal frames at the end of each span have a lattice-work arrangement which partially mimics the original.

The floor system comprises W30 rolled floor beams between trusses, with welded tapered segments cantilevering beyond for sidewalk support, and WWF18 longitudinal stringers on top of the floor beams. The stringers are supported on the floor beams on a mix of fixed, guided, and free-sliding bearings to provide a partially-floating grid that does not attract excessive structural load from the trusses. Figures 13 and 14 shows the typical cross-sections of the new bridge.

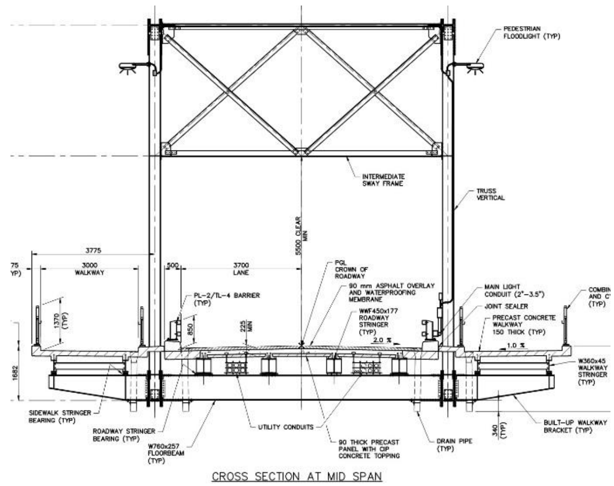


Figure 13 – New Bridge Midspan Cross-Section

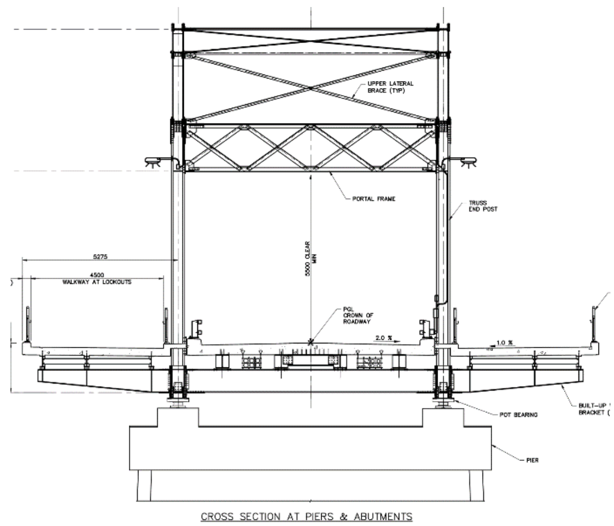


Figure 14 – New Bridge End Cross-Section

During the bid design, the design and contractor team worked with a steel fabricator, Supreme Steel, in the development of pricing. Once the job was won, Supreme was awarded the steel fabrication and erection contract, and worked with the COOWI designers during detailed design to develop optimum connection details. Supreme fabricated the steel in their Saskatoon shop, which was well suited to the multiple small parts required. All of the members in the truss and floor system use bolted connections, and optimizing the layout and number of bolts was an important design priority.

Figures 15, 16, and 17 show some typical truss connections.

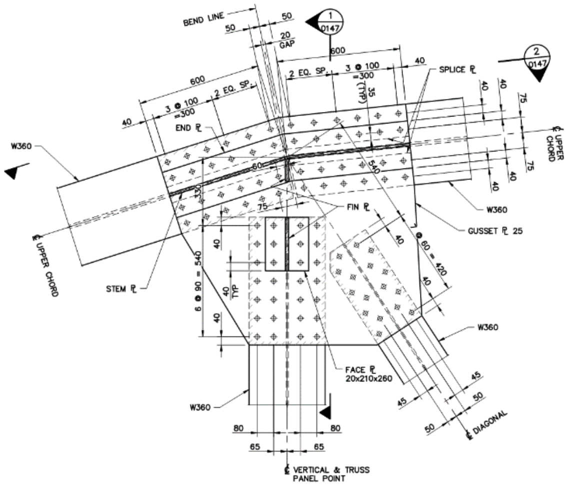


Figure 15 – Typical Top Truss Connection

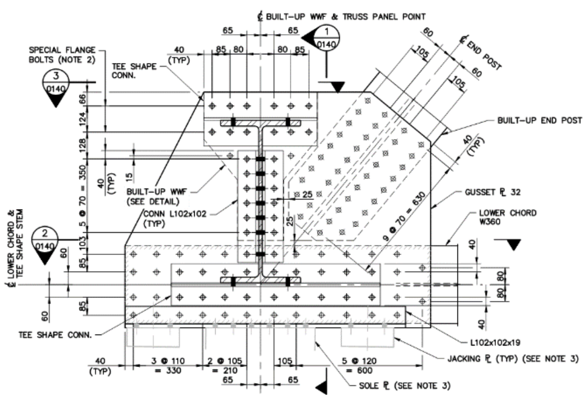


Figure 16 – Typical Bottom Truss Connection

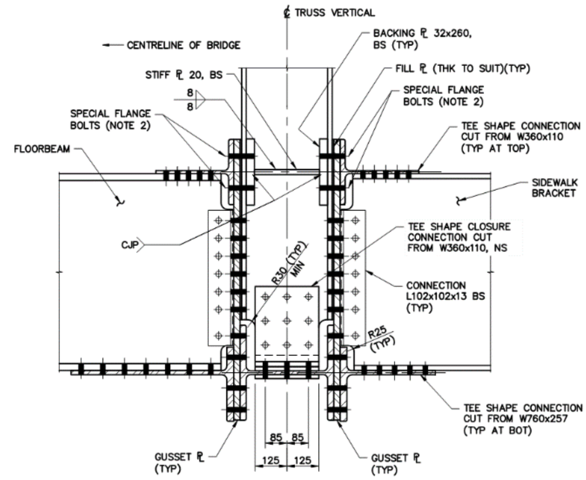


Figure 17 – Typical Floor Beam Thru-Connection

The Project Agreement required the use of Service Life Design with a Service Life specified as 100 years. For the Traffic Bridge steel components, exposure zones for various severities of exposure were developed, and corrosion allowances and paint systems were specified based upon these zones. Figure 18 illustrates the use of these zones.

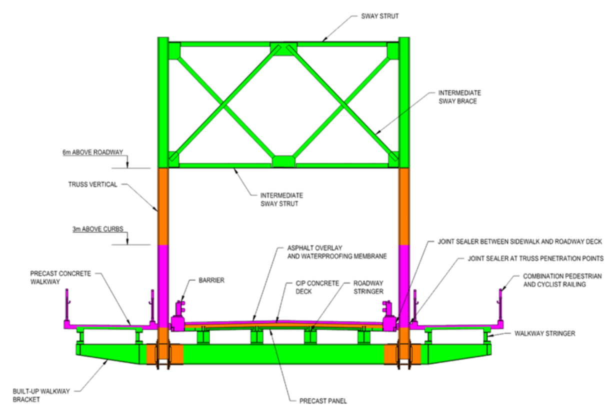


Figure 18 – Service Life Exposure Zones

Weathering steel, CSA G40.21 Grade 350AT Category 3 (equivalent to ASTM A588 with notch toughness specified) is used for all main structural elements. Bolts are ASTM A325, typically 7/8 in diameter. In the high exposure zones near the roadway, the steel is painted, elsewhere it is left unpainted.

One of the keys to efficient construction for this bridge is the system of precast deck and sidewalk panels. The layout of this system for a single span is shown in Figure 19.

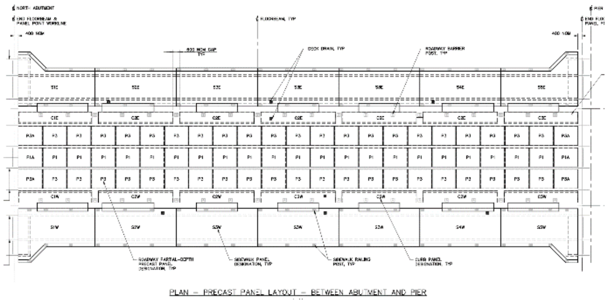


Figure 19 – Precast Panel Layout

The use of precast elements, some of them (sidewalk panels) cast integral with the steel stringers, not only provided formwork and access savings and improved concrete quality, but allowed much of the deck construction to proceed independently of the weather, which in Saskatoon included a long, cold winter.

Between the steel stingers under the roadway, three rows of partial depth precast panels are set on foam haunch blocks on the stringer flanges. On the outside of each exterior stringer, a cantilevered full-depth precast curb unit is set, with rebar projecting into the cast-in-place concrete over the partial-depth precast. The cast-in-place concrete is screeded on the top surface of the curb units, and the deck is not very wide, so no deck machine was required. A waterproofing membrane and asphalt pavement will complete the deck.

Outboard of the trusses, the sidewalks were precast onto steel supporting frames in the plant and erected as complete panel-length units, see Figure 20. The surfaces of these sidewalk panels are stamped to resemble timber decking, see Figure 21.

Figure 20 – Precast Sidewalk Unit

Figure 21 – Stamped Concrete Sidewalk Surface

Construction

The construction of the new Traffic Bridge commenced early in 2016. The primary means of access into the river for demolition of the original bridge, pier construction, and superstructure erection involves the use of rock and clay berms built out from the river bank, first from one bank and then from the other in a sequence that always left enough river width for required flows and the small amount of water traffic that takes place.

Construction began by pushing the berm out to Pier 2 in the river, allowing Spans 3 and 4 to be demolished onto the berms using explosives, see Figure 22.

Figure 22 – Explosive Demolition of Spans 3 & 4

The berm was then partially pulled back, and Pier 3 was rehabilitated working from the berm, while Pier 4 was demolished and the new South Abutment built nearby. A smaller berm was built on the north side to allow demolition of Span 1 and was then removed; this allowed for the construction of the new North Abutment. This sequence meant that for a while, there was a lone old span out in the middle of the river that would not be demolished until later, see Figure 23.

Upon completion of the new South Abutment and Pier 3, the steelwork for Span 4 was erected. Falsework was erected along the berm, allowing the truss bottom chords, floor beams, and entire floor system to be erected before erecting the remainder of the truss steel and overhead bracing. The berm also allowed for the use of manlifts for all bolting work. See Figure 24.

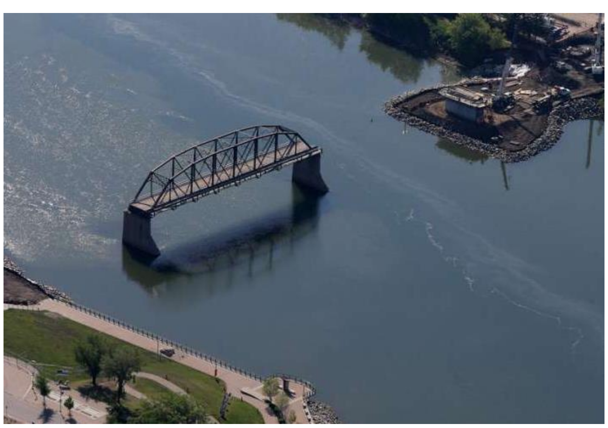


Figure 23 – Last Old Truss Span Alone in the River

Figure 24 – Erecting Truss on Falsework

Figure 25 shows the new Span 4, looking through at the last original span remaining over the river.

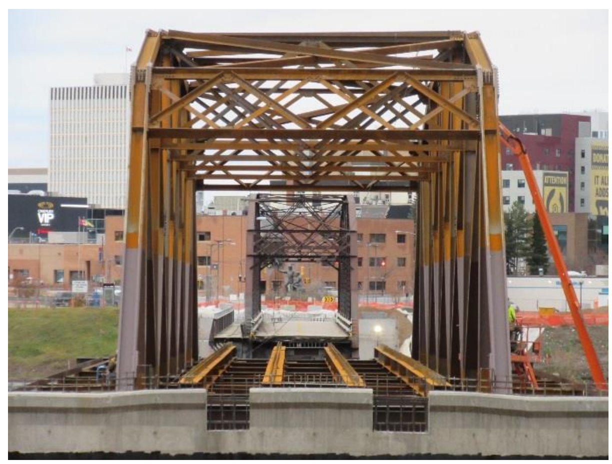


Figure 25 – The New and the Old

After the Span 1 steel was erected, camber checked, and bolting completed, precast concrete panels were placed by crane before the berm was removed.

The next step in the berm deployment was to build a berm out to Piers 1 and 2 from the north shore. This allowed the final span to be demolished and Piers 1 and 2 to be reconstructed, see Figure 26.

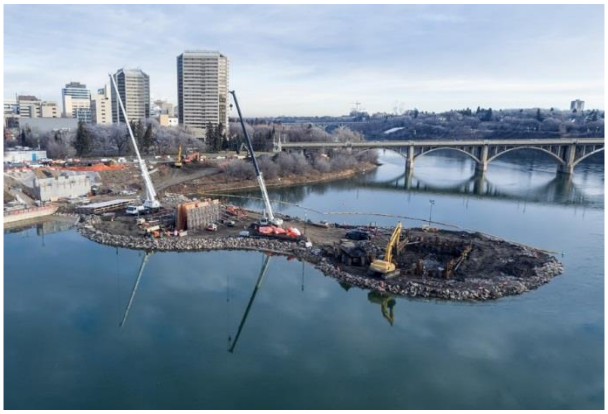


Figure 26 – Berm for Piers 1 and 2

A temporary bridge was then installed from the north shore, and the berm moved out to become an island under Spans 2 and 3, allowing the erection of these new spans from this berm. The final step was to pull this berm back to beneath Span 1, allowing the erection of the steelwork and precast there, then the final berm was removed from the river.

Final steps for the main superstructure elements was to complete joints between precast panels, install deck joints, and cast the upper portion of the decks. Figure 27 shows erected sidewalk panels while Figure 28 shows a completed concrete deck.

Figure 27 – Sidewalk Panels in Place

Figure 28 – Completed Concrete Deck

At the time of writing, final steps for the bridge construction were underway, such as curb construction, pedestrian railings, traffic barriers, retaining walls, pathways, deck pavement, and completion of the small overpass bridge to the south. The project is on schedule and slated to open in October of 2018.

Conclusions

Not too many roadway bridges are built today as steel trusses with spans of only 200 ft. The form of this particular bridge was driven by the community's desire to see the new bridge have a similar appearance to the original, historic bridge. The project showed that this could be achieved, with a modern, durable steel bridge structure with innovative details that ensured it was constructable in an efficient and affordable manner.

There seems to have been some success with the goal of having the new bridge appearance reflect the old: during construction, after the last old span had been demolished and the first new span was already up, the City was reportedly getting calls from members of the public wondering when the last old span would be blown up – when they were actually looking at the new span.

Acknowledgements

City of Saskatoon

Graham Construction Ltd.

HistoricBridges.org