Slide-in Bridge Construction using the Construction Manager General Contractor, Contract Delivery Model

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Abstract:

In 2017, the Ontario Ministry of Transportation (ministry) successfully completed the replacement of the Highway 3 Grand River Bridge at Cayuga, Ontario. The existing bridge constructed in 1924 was a five span, 188m long, steel through truss bridge. This complex project included a number of “firsts” for the ministry. This was the first project in Ontario that was delivered using the Construction Manager General Contractor (CMGC) contract delivery model. The project also included a number of innovative solutions, such as slide-in bridge construction of a 188m five span structure, through collaboration with the contractor during the design phase.

The CMGC model is still a relatively new contract delivery model for the ministry. The intent of CMGC is to form a collaborative team, between the owner, designer and a contractor, which begins in the design phase and continues throughout construction. During the design phase the contractor provides construction expertise and constructability input into the design with the intent to become the general contractor.

This paper provides an overview of the CMGC delivery model, and discusses the rationale for selecting the CMGC contract delivery model for the bridge replacement project in Cayuga. The paper also describes technical solutions developed and implemented by the collaborative CMGC team during both the design and construction phases of the project. Some of the design challenges of the project included the need to construct the replacement bridge while maintaining two-way traffic on the existing bridge; geotechnical challenges related to fractured voided bedrock; the need to maintain existing utility lines across the bridge during the bridge demolition and bridge slide operations; and the need to minimize impacts to the bed and banks of the river.

Furthermore, adding to the complexity of the project, during construction, work was stopped for a period of 17 months while the new bridge was sitting on temporary supports and the existing bridge had already been demolished. The CMGC approach again played an important role, enabling the ministry to effectively manage this unforeseen delay through the collaborative relationship developed with the ministry, designer and contractor.

Following the successes achieved on this complex project, the ministry has extended the use of the CMGC delivery model to a number of other complex projects.
1 Introduction

The design and construction for the replacement of the Highway 3 Grand River Bridge was the first project in Ontario that was delivered using the Construction Manager General Contractor (CMGC) contract delivery model. The objective of the project was to replace the bridge while maintaining two-way traffic across the river throughout construction and developing a design that minimizes impacts to the bed and banks of the river.

Technical information provided within this paper was obtained from various documents prepared by the design consultant, construction manager and their sub-consultants/contractors during the design and construction phases of the project.

2 Project Background

The Highway 3 Grand River Bridge is located at the west side of the town of Cayuga, Ontario. The bridge is an essential part of the local and regional transportation network as it is the only river crossing in the local Cayuga area.

The existing bridge was a 188 metre long five-span steel through truss, originally constructed in 1924, and had reached the end of its’ life. To extend the service life of the bridge, the Ontario Ministry of Transportation (ministry) completed major rehabilitation work on the bridge in 1976 and 1988. In order to maintain the rapid declining condition of the bridge, repairs to critical structural steel members were completed in 2001, 2005, 2007, 2009 and lastly in 2012 to extend the service life of the bridge until the bridge was replaced. In 2010 weight restrictions were placed on the bridge and the structure was also being monitored remotely through an intensive structure health monitoring program.

To address the deteriorated condition of the bridge, in 2005 the Ministry initiated a Preliminary Design (PD) and Class Environmental Assessment (EA) Study to identify and evaluate rehabilitation and replacement alternatives to address the structural deficiencies of the existing bridge. The Study received Environmental Clearance on December 17, 2008 and recommended:

- replace the existing bridge with a new structure on the existing alignment; and
- provide access across the Grand River throughout construction through installation of a temporary modular bridge constructed adjacent to the existing bridge.

Figure 1: The Existing Grand River Bridge
3 Project Key Challenges

With the decision to replace the bridge, the PD and EA Study identified several challenges that needed to be addressed further in the detailed design phase of the project. These key challenges are discussed below.

3.1 Traffic Staging

Highway 3 is the principle east-west route in the local area and the Grand River crossing is an integral component of this route. For commuters and emergency services, the bridge is particularly important due to the limited number of roads that cross the Grand River in the area. The nearest alternative crossings of the Grand River are located at York, 10 km to the north, and at Dunnville, 20 km to the southeast.

As a result, detouring traffic to other roads for two years of construction was not a viable option. The PD study recommended detouring Highway 3 traffic to a temporary modular bridge constructed south of the existing bridge (see figure 2).

Figure 2: Preliminary Design Plan

3.2 Archaeology

During Preliminary Design, an archaeological assessment of the area surrounding the Bridge confirmed that the Grand River has an extensive history of prehistoric occupation and confirmed that cultural materials are present on the west side of the Grand River in the project study area.

To protect the archaeological resources, during Preliminary Design the ministry was advised by the approving agencies that any works resulting in permanent impacts to the west banks of the Grand River would require excavation and retrieval of all archeologically significant artifacts from the affected area. However for any temporary works, such as detour alignments, it was determined that “temporary capping” of archaeological resources would be acceptable to the approving agency.
Soon after Preliminary Design was complete, the ministry initiated the detailed design phase of the project in October of 2009. Early in detailed design, the Ministry was advised by the approving agencies that “temporary capping” of buried archaeological resources would no longer be considered acceptable. This change now imposed the requirement to complete an archaeological salvage for all works including any temporary works ensuring all buried artifacts are recovered before the start of construction.

This decision came with substantial impacts to both the project schedule and budget. It was determined that about 350 m² of archaeological salvage was required to accommodate the permanent works and about 1330 m² of “temporary capping” would have been required to implement the Preliminary Design approach (temporary modular bridge detour approaches). Completion of an additional 1330 m² of archaeological salvage would delay the start of construction up to 4 years and result in additional costs in the order of $2 to $3 million.

3.3 Utilities

The existing bridge carried natural gas and telecommunication utility lines. The natural gas line was suspended from the north side of the bridge and four ducts carrying a combination of copper and fibre optic telecommunication cables were attached to the bottom chord of the south truss. Removal and relocation of the utilities was investigated, however it was determined that no viable alternative river crossing was available. As a result, it became a project requirement to maintain these utilities throughout construction and transfer them onto the new bridge.

3.4 Environmental Constraints

In the vicinity of the Bridge, the Grand River supports several aquatic ‘Species at Risk’ (SAR), including fish, turtles and several freshwater water mussel species.

Mitigation strategies to protect aquatic species included adhering to a warm-water construction timing window (restricting work to between July 1 and March 15) for all required in-river work and relocating resident mussels prior to the start of the work. The relocation of mussels is temperature sensitive and could only be planned to occur between June and August, when water temperatures are warmer and mussels remove themselves from the riverbed. With the first construction activity scheduled to be installation of the temporary bridge foundations, the relocation of the mussels became the critical scheduling activity. For example, if the mussels are not relocated in the summer of 2012, construction on the project could not proceed until the fall of the following year, after the mussels are relocated in the summer of 2013.
3.5 Poor Foundations
At the bridge site, bedrock is found beneath a variable layer of sand and gravel (0.2m to 2.2m in depth). Foundation investigations confirmed that the upper layer of bedrock is comprised of very poor quality fractured dolostone and is characterized as voided rock containing voids up to 600 mm. The lower layer of bedrock was considerably better quality and was described as being slightly weathered medium strength dolostone.

3.6 Built Heritage
The existing steel through truss bridge was a physical landmark, well known in the Cayuga area. The Study recognized the existing bridge as a heritage structure and as a result, to address Built Heritage concerns, sympathetic features that recognize and commemorate the original bridge were included in the new bridge design. Two of the most recognizable features included low level pedestrian lighting and a wave patterned steel railing attached to the outside of bridge barrier (see figure 13).

4 CMGC Model & Procurement

4.1 Why Implement CMGC on this Project
Primarily to address the archaeological issue discussed in section 3.2, the ministry initiated the CMGC alternative project delivery model in order to promote innovation to reduce or eliminate impacts to the archaeological site, while continuing to meet the needs of the local community such as maintaining traffic and utility services during construction.

4.2 CMGC Concept
The CMGC delivery model is an integrated team approach to the planning, design and construction of a highway project. This delivery model involves hiring a Contractor/Construction Manager (CM) to actively participate in the design phase of the project with the goal of becoming the General Contractor (GC) and constructing the work for a Guaranteed Maximum Price (GMP). The CM enters into a contract with the Ministry to provide construction manager services throughout design and is paid a fee for these services (see section 7 for further details on cost).

Although the ministry retains overall project management and leadership for the project, the intent is to form a collaborative team with the ministry (the owner); the designer working for the ministry, and a contractor working as the CM. An important role of the CM is to help identify and assist in the management of project risks and be relied upon to provide the following during the design phase of a project:

- provide innovative and alternative construction approaches;
- provide skills and knowledge to estimate quantities of materials, labour and equipment needed;
- continually provide input on schedule, phasing and constructability; and
- undertake formal plan reviews.
Following completion of the design, the contractor prepared and submitted a GMP (bid price) based on the plans and specifications developed during the design phase of the project. If the GMP was accepted by the Ministry, both parties enter into a contract for construction of the project, and the Construction Manager (CM) becomes the General Contractor (GC). If the GMP was not accepted by the Ministry, the contractor’s services under the CM Services contract are terminated. The Ministry, in its sole discretion, then has the opportunity to procure the construction contract by some other method incorporating all or part of the collaborative design.

4.3 CMGC Procurement

On January 13, 2011, the ministry publicly advertised a Request for Proposal (RFP) document inviting contractors to submit proposals to participate on this project. On March 17, 2011 the ministry received eight (8) proposals in response to the RFP.

The proposal submissions consisted of a 2-part submission, a Technical Proposal and a Price Proposal. The Technical Proposals were evaluated first prior to opening the Price Proposals.

Technical Proposal

The Technical Proposal submissions included discussions on several topics, such as:

- **Contraction Manager Team** – present the team members, including their qualifications and relevant experience.
- **Project Approach** - proponents state their approach to constructing the work
- **Alternative construction Approaches / Innovations** – present their alternative approach to constructing the work and discuss how their alternative approach will address the project key challenges and achieve the project goals
- **Approach to Price** – proponents described how their Alternative Approach will increase or decrease the bid item prices submitted in their Price Proposal and discuss changes in cost of the overall project relative to the original approach presented by the owner (i.e. the Preliminary Design).

Price Proposal

The Price Proposal submission required the proponents to submit prices for a select number of bid items. For this project, a total of nine bid items were chosen, including such items as: “Concrete in Deck”, “Removal of Bridge Substructure” and “CM Services” during design. The bid item prices the proponent submits at the proposal stage are based on constructing the owner’s original design concept (i.e. preliminary design) and become the prices for the same bid items when the contractor submits a price (at the design complete stage) to construct the work unless there is a clear justification for change.

After the proposal evaluations were complete, it was determined that the highest ranking Proposal was submitted by Dufferin Construction Company Ltd., Oakville, Ontario (Dufferin Construction). In April 2011, Dufferin Construction joined the collaborative design team which included the Ministry (the owner) and McCormick Rankin Corporation (the designer).
4.4 Design Enhancements Realized through the CMGC Model

Alternative Staging Approach

Implementation of the CMGC delivery model led to the development of an alternative construction staging approach and eliminated the need for the temporary modular bridge proposed during the Preliminary Design phase.

The proposal submitted by Dufferin Construction identified the use of a lateral “Jack and Slide” technique, where the existing bridge would remain open to traffic while the new bridge superstructure is built on temporary piers immediately adjacent to the existing structure. Once the new bridge superstructure is in place, traffic would be diverted onto the new bridge in its temporary location. The old existing truss bridge superstructure including the pier caps would be removed, and the remaining piers shafts rehabilitated, followed by the construction of new pier caps and new abutments. Finally, the superstructure of the new 188 metre, continuous five-span bridge would be slid onto the rehabilitated piers on the bridge’s existing alignment.

Complexities of the Bridge Slide

One of the important features of the staging concept is the proximity of the new superstructure built adjacent to the old bridge. The new bridge deck, once it was constructed in its temporary location overlapped the construction of the new pier caps and there was only 80 mm of separation between the temporary and new pier caps (see figure 5). By keeping the two structures close together, the highway approaches to the detour structure *(i.e. the new superstructure on temporary piers)* could be confined within the existing highway right-of-way (see figure 7). This allowed the project team to meet one of the key project goals which was to avoid additional impacts to the archaeological resources on the west banks of the river.

![Figure 4: New bridge sitting on temporary piers, built within 80 mm of the new pier caps](image-url)
The existing telecommunication lines located on the existing bridges bottom chord of the south truss needed to be temporarily supported to allow the existing bridge trusses and pier caps to be removed. The location of the utility line was located between the old bridge and the new superstructure, requiring the new superstructure to be slid overtop of the utility lines. Through collaboration with the designer, contractor and the utility owner, a strategy to manage the utility lines in-situ was developed. This is discussed further in section 6.3.

Figure 5: Schematic showing the separation between the two structures

5 Roles and Responsibilities

Under the CMGC delivery model, the ministry retains overall project management and forms a collaborative team with the designer and the contractor. This delivery model allowed the ministry and its contractor and designer to work together during the design phase to develop solutions that met the project goals. The collaboration created an environment where the contractor had the opportunity to optimize the bridge slide system based on their equipment and experience and discuss the risks and constructability issues early in the design phase. This discussion allowed the bridge design to be modified to accommodate the preferred bridge slide system.
In most cases in a traditional design-bid-build project, the ministry would work with a designer to complete the design of all permanent bridge components and after the design is complete, the contractor would then be responsible for the design of temporary works such as temporary piers and the bridge sliding system. This project, using the CMGC model, provided the opportunity for the temporary works to be discussed and developed during the design phase. While the ultimate responsibility for design of the temporary works remained with the contractor, completing this design work early allowed all parties to fully understand the risks and challenges associated with the work.

For the bridge slide operation, the responsibilities that remained completely with the owner were:

- Setting expectations for lane and highway closures allowed for the work; and
- Defining limitations and expectations of the bridge jacking operation (see section 6.4).

6 Design and Construction Features

6.1 Reuse of existing substructure

During detailed design, it was determined that the existing piers required significant modifications to support the new superstructure configuration. The foundations investigation confirmed the existing supporting material bedrock was performing well, but recommended the fractured bedrock be injected with a non-toxic chemical grout to address the potential cavities in the rock. Construction of new footings was also considered, but imposed significant environmental challenges with constructing in the river. The original pier shafts were unreinforced concrete built before concrete air-entrainment became common and showed signs of minor age-related deterioration but overall were identified to be in good condition on average.

A strategy was developed by the design team to eliminate in-water work by carrying out all pier rehabilitation suspended from the piers or from barges. The existing pier caps were fully removed and the remaining pier shafts were core drilled Ø325mm full height with a drilling rig to install micropiles down through the bedrock. The final design included installing 18 micropiles at each pier which extended through the pier shafts and the underlying riverbed material and were embedded approximately 11 metres into the underlying bedrock (see figure 5). The shaft resistance of the micropiles was relied on to provide the foundation capacity for the new superstructure. All access for the micropile construction was provided from a working platform on the existing piers and from shallow draft barges (see figure 6). New pier caps were constructed on the existing shafts, encapsulating the top of the micropiles.
Figure 6: Micropile operation showing first two piers with completed micropiles and the drill rig on top of the third pier.

6.2 Temporary Bridge Approaches

Transferring traffic from the existing Highway 3 alignment to the new bridge built in its temporary position, was completed with the use of closely spaced horizontal curves, temporary bridge approach spans and a five metre high retained soil system (RSS) wall (see figures 7 & 8). These design features ensured the temporary highway works were confined within the existing highway right-of-way and avoided additional impacts to the buried archaeological resources and avoided the need to infill the river to accommodate a temporary abutment.

With a posted speed limit of 50km/hr across the bridge, the superelevated curvilinear highway alignment on the approaches included the use of 250 m radius curves on the west approach and 160 m radius curves on the east approach to the bridge. The abrupt reversal in the alignment was suitably designed by introducing back-to-back spirals between the two curves at each end of the bridge.

Using the CMGC model provided the opportunity to discuss the use of temporary RSS walls and temporary bridge approach spans including verifying their constructability during the design phase. While the ultimate responsibility for this temporary work remained with the contractor, all parties participated in the conceptual design. The RSS wall was constructed with the use of the TerraSteep 90 system by the Terrafix Company and the temporary bridge approach spans were designed and fabricated by the contractor. The temporary approach bridges were simply supported girder structures with a span of 14 m and a deck width of 10.9 m supported by four W920x201 girders.
6.3 Utility Management

To maintain utility lines and service across the river a unique approach was developed by the CMGC team and the utility owners. The natural gas line that was attached to the existing bridge was decommissioned and a temporary line was installed on the new structure in its temporary alignment and remained there until the bridge slide. In the hours preceding the bridge slide the temporary gas line was purged and disconnected to accommodate the bridge slide. A new permanent gas line was installed on the north fascia of the new bridge prior to the bridge slide and was put into service immediately following the bridge slide.
The telecommunication lines presented more of a challenge as the lines could not be disconnected, rerouted or removed from service for any length of time. Further to this, the lines needed to remain above the piers to avoid spring river ice flows and there was limited slack available in the lines to allow for significant changes in the vertical profile. These requirements became very challenging considering the primary objective of the project required the bridge to be slid over the lines.

To maintain the lines in place, a 5/8" steel carrier cable was suspended across the river and the lines were secured to the steel carrier cable. Turnbuckles were installed into the face of each abutment to provide anchorage for the steel carrier cable. To accommodate the bridge slide operation, the utility lines were temporarily lowered into a formed block-out in the pier caps and the new bridge was slid over the protected telecommunication cables to its final position (see figure 9).

This strategy which required significant cooperation from the utility owners avoided the need for multiple costly utility moves, and was completed with no service interruption to the utility.
6.4 Bridge Sliding System

A literature review of similar bridge slides at the time of construction yield a small number of projects where sliding of a newly constructed multi-span continuous structure had been completed. It was noted that a few US DOTs, especially Utah and Iowa, have embraced slide-in construction and have built a number of single span bridges or slid multi-span bridges one span at a time and connected them after. Although this type of work is not common, its use has been increasing and the ministry has previously used this technique on several projects, including at Highway 403/Aberdeen Avenue, Hamilton in 2010 and at Highway 406/Glendale Avenue, St. Catharines in 2015. The Grand River Bridge at Cayuga is one of the longest bridges to be constructed by the ministry using this method.

To ensure adequate structural performance during the slide of the continuous superstructure, robust tolerances were specified to ensure the slide was carried out in a uniform manner, such that all jacking points would be maintained in a parallel alignment to a set reference line. In the end, a tolerance of 7mm chord deviation from two adjacent piers was permitted after review of potential jamming scenarios by the contractor’s jacking designer and the design engineer. The tolerance would also take into account any thermal related movement naturally occurring in the structure prior to jacking. The tolerances satisfied the conditions that cracking would not be induced in the bridge deck, plastic deformation of the steel would be precluded, and slip of bolted connections would not occur.

The sliding system required a significant amount of work on-site leading up to the actual slide event. The lead up work took approximately three weeks to complete and is discussed further below.

In order to accommodate the cross-fall on the bridge deck, varying height steel pedestals were designed with a cruciform section, beveled shoe plate and base plate that would later rest on a level slide surface (see figure 10). The slide system included a slide path constructed with a series of 12mm thick plates installed continuously on the final concrete bearing seats and temporary pier bents. The 12mm plates were joined together using a central guide bar as shown in figure 11. The bearing seats were grouted below the slide path as required to provide a surface that was dead level.

To start the lateral slide, the bridge was jacked vertically and placed on Hillman rollers supported directly on the steel slide path. The slide was executed using twelve (2 at each pier/abutment) 30 ton long stroke hydraulic jacks capable of extending 150mm per stroke. The jacks were braced off a gripper assembly clamped to a central guide bar that had been welded to the slide path. After each push sequence the gripper was retracted to the advanced slide position and reset to repeat the operation. The slide procedure and gripper assembly were designed to allow for re-deployment in the opposite direction at any jacking location in the event a correction was needed. All of the jacks were discretely instrumented and were continuously monitored from a central control hub. Displacement was measured using linear transducers, capable of accuracy to 1mm. The central control hub was equipped with limit stops based on pre-determined hydraulic pressures or displacements at individual jacking points.
The new bridge was initially scheduled to be moved laterally approximately 13 metres onto the rehabilitated bridge piers on August 27, 2016, during a 36-hour full closure of the bridge to traffic.

At 12:00 am on August 27, 2016 Highway 3 was closed at the Grand River Bridge in Cayuga. The bridge slide then commenced in the early morning hours on August 27, 2016 around 7:00 am and was placed into its final alignment seven hours later at approximately 2:00 pm.

The highway was reopened ahead of schedule on August 27, 2016 at approximately 8:00pm. Overall, Highway 3 was closed for a total of 20 hours.
7 Cost Considerations

Lateral Bridge Slide

It is recognized that SIBC comes with some additional costs, however, the use of slide-in-bridge construction can result in overall savings to a project. When considering the use of SIBC, the cost of implementing the lateral slide must be compared and evaluated against the overall project costs and not be seen strictly as an additional cost.

Table 1 below provides a summary of the major cost differences between constructing the ministry’s preliminary design approach which included use of a Temporary Modular Bridge (TMB) and the final design which implemented the SIBC approach. The “Lateral Slide + Enhanced Temporary Piers” item includes the cost bid by the contractor to complete the lateral slide and the increased cost to construct the temporary piers, when compared to the temporary piers contemplated during preliminary design. The “Temporary Modular Bridge” item shows the cost estimated during the preliminary design for the supply, installation and removal of the TMB. The “Archaeological Salvage” item is an estimated cost to complete an additional 1330 m² of archaeological salvage required to implement the preliminary design approach and was based on bids received to complete 350m² of archaeological salvage for the final design.
Table 1: Cost Increases and Decreases with use of SIBC vs. the Preliminary Design Approach

<table>
<thead>
<tr>
<th>Work Item</th>
<th>Increase</th>
<th>Decrease</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral Slide + Enhanced</td>
<td>$1,300,000</td>
<td></td>
<td>Temporary supports where required to support full bridge loading and accommodate ice loads and all other loads resulting from jacking and relocation of the superstructure.</td>
</tr>
<tr>
<td>Temporary Piers</td>
<td></td>
<td>-$2,840,000</td>
<td>The need for the TMB was eliminated</td>
</tr>
<tr>
<td>Temporary Modular Bridge</td>
<td></td>
<td>-$2,470,000</td>
<td>The final design eliminated the need to complete the archaeological salvage for the detour alignment proposed in the preliminary design.</td>
</tr>
<tr>
<td>Archaeological Salvage</td>
<td></td>
<td>-$1,300,000</td>
<td></td>
</tr>
</tbody>
</table>

$1,300,000 - $5,300,000

The implementation of SIBC on this project, presented an opportunity for cost savings in the order of $4M on the overall project. The savings resulted primarily from the elimination of costly temporary works and reducing archaeological salvage work. In addition, eliminating the need for completing the additional 1330m$^2$ of archaeological salvage reduced the delivery time to construction by approximately 2-4 years.

CMGC – CM Services Cost

To date the Ministry’s West Region has awarded four CM Services contracts under the CMGC delivery model. When considering these four contracts, it is found that the cost of the CM services has been in the range of 0.4% – 1.0% of the projects estimated construction cost.

8 Construction Schedule

On June 11, 2013, the Ministry awarded the construction contract to complete the overall bridge replacement work to Dufferin Construction. It was at this point, that Dufferin Construction switched from providing Construction Manager (CM) services on the project to being the General Contractor (GC).

The original construction contract included a final completion date of August 7, 2015, along with two key interim completion dates. The new superstructure was to be built and traffic switched onto the temporary alignment in June 2014 and the lateral slide was to occur prior to May 15, 2015. To avoid disconnecting natural gas service during the winter months, the construction contract included a constraint that restricted the lateral slide from occurring during the winter (November 15 to April 1).

Commencing on July 15, 2013, the contractor mobilized cranes and barges to begin their work. The first major milestone was to complete the construction of the temporary bridge piers. The temporary pier construction which required deep foundations to be installed (see figure 5) was a lengthy operation and was completed on December 3, 2013. Erection of the bridge girders onto the temporary piers followed and took 15 days to complete. During the months of January, February and March of 2014 the river was frozen-over and access which was normally by barge was no longer a viable option. As a result, work on-site focused on forming and placing reinforcing steel for the new bridge deck. The new bridge deck concrete was placed in three separate pours. The first pour occurred on April 28, 2014 and the final pour was completed May 13, 2014. Approximately one month later, after bridge deck waterproofing, paving, lighting and
traffic barrier installation, the new bridge in its temporary position was opened to traffic on June 20, 2014.

With traffic removed from the existing bridge, which carried traffic for 90 years, the existing trusses were then removed. The truss demolition process took approximately 6 weeks to complete, and was finished by August 29, 2014. Removal of the existing abutments and pier caps followed the truss removals, and once the pier caps were removed installation of the micropiles down through the piers commenced. The work which required 72 micropiles (18 per pier) to be installed was initially scheduled to require 80 working days to complete. The micropiling operation commenced in September 2014 and was approximately 75% complete by November 4, 2014.

On November 4, 2014 work on the project came to a stop. Aside from some work to secure the site for winter, work on the project was paused for a period of 17 months from November 4, 2014 to April 2016. During this period there were ongoing discussions between the ministry and the Haudenosaunee Confederacy Chiefs Council.

Recommencing in April 2016 presented a schedule challenge. The originally scheduled sequence for the remaining operations was the following: remobilize barges and cranes; complete the micropiling operation; re-face the concrete pier shafts; construct the pier caps; and jack and slide bridge. If the original sequence of operations was to be followed, the lateral bridge slide would not occur until November 2016.

At this point in time, with the temporary substructure already in service for longer than expected and exposed to one additional winter, there was reason to accelerate construction to provide certainty the bridge is removed from its temporary piers and not exposed to another winter. Working together the ministry and the contractor developed a strategy to accelerate the work. Among other changes, the project team elected to remove the pier re-facing from the schedules critical path and rebuild the pier caps first followed immediately with the lateral jack and slide operation. This strategy allowed the bridge slide to occur in August 2016.

Following the bridge slide, approximately 2 months was required to complete the pier re-facing, expansion joint installation, south wingwall construction, paving, electrical etc.. By the end of 2016 the bridge was essentially complete.

9 Conclusion

The use of slide in bridge construction provides an alternative to staged construction, temporary bridges or long-term full closures of highways. The selection of SIBC must be compared against all the project factors including costs, schedule and user costs such as maintaining traffic and avoiding traffic delays. The use of SIBC becomes a competitive option on projects that are required to maintain traffic and would otherwise require the use of a temporary bridge for more than one construction season.

It is the opinion of the authors that the CMGC delivery model provided the opportunity to explore innovative construction techniques and implement a unique construction staging strategy, which in a traditional project delivery model may not have been carried forward due to construction challenges and the associated risks.
The CMGC delivery model allowed the three design team members (owner, designer, contractor) to better understand the capabilities and strengths of the other parties. This understanding allowed all members to make contributions to the design, and most importantly, gives a sense of ownership of the design/project to all members involved, including the contractor.

Recognizing that the inclusion of a contractor into the design team proved to be a significant benefit on this project, the ministry will continue to explore opportunities to implement the CMGC delivery model on large complex projects where the project would benefit from early contractor involvement.

Figure 13: Completed bridge

Acknowledgments

The authors would like to thank the Cayuga Bridge project team, which included MTO staff, McCormick Rankin Corporation (the designer), Dufferin Construction Company Ltd. (the prime contractor), Western Mechanical Ltd (bridge jacking subcontractor) and Brown & Co. Engineering Ltd. (bridge construction engineering specialist) and all other sub-contractors and sub-consultants for the collaborative partnership throughout the design and into the construction of this project.

REFERENCES