HEAVY MOVABLE STRUCTURES, INC.
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Bridge 6
Major Rehabilitation

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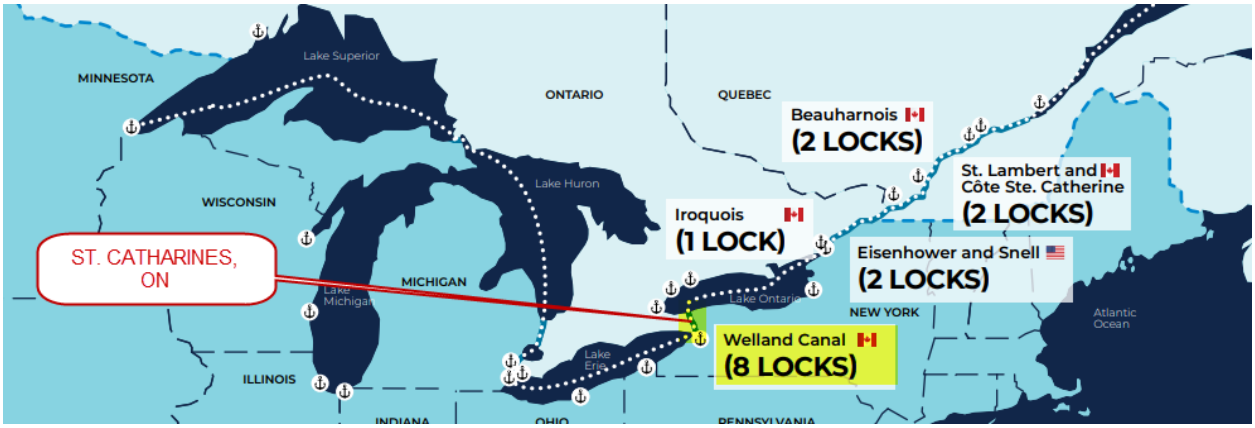
RENAISSANCE HOTEL
ORLANDO, FLORIDA

Introduction

The St. Lawrence Seaway is a commercial waterway that travels from the St. Lawrence River in Montreal to Lake Erie (Port Colborne). The Welland Canal portion of the St. Lawrence Seaway is from St. Catharines, Ontario (south end of Lake Ontario), to Port Colborne, Ontario (north end of Lake Erie). The canal is 43 km (27 miles) long and has an elevation change of 100 m (330 ft) across the entire length.



Location Plan of the Great Lakes Seaway

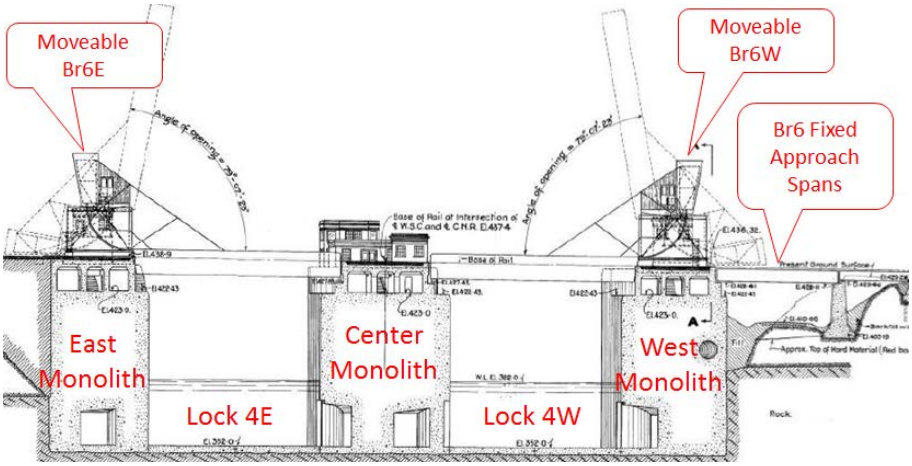
Bridge 6 is a rail bridge located at the North end of the flight Locks No. 4 East and No. 4 West in St. Catharines, Ontario, Canada. The bridge carries a double track rail line (East and West direction) over the Welland Shipping Canal (North and South direction) and over the adjacent Welland Canals Parkway and Pedestrian Trail (North and South direction). The rail line provides main rail access between Greater Toronto-Hamilton Area and the United States via Niagara Region. Bridge 6 is managed, operated and maintained by The St. Lawrence Seaway Management Corporation (SLSMC) while the rail tracks are owned and maintained by CN Rail (CNR). The tracks are used by various rail companies including CNR, Metrolinx (MX), Via Rail (VIA) and Amtrak (AMT).

Location Plan of the Welland Shipping Canal in the Niagara Region

Location Plan of Bridge 6

Bridge 6 was designed between 1926 and 1927, fabricated between 1929 and 1930 and has remained operational since 1932. The bridge currently cycles approximately 2,500 operations per span per year and allows up to approximately 3,650 train crossings each year. The bridge is operated remotely from the SLSMC's Operations Control Center within the Niagara Region Administrative Building, located approximately 500m (1650 ft) North-West of the bridge. Bridge 6 is critical to the safe and reliable operations of several stakeholders: transit of vessels by SLSMC, transit of freight trains by CNR and transit of passenger trains by MX, VIA and AMT.

The bridge structure consists of two single leaf Scherzer style rolling bascule spans (East and West) and two adjacent deck plate girder fixed approach spans which are located to the West of the moveable spans. The steel girders are of riveted construction, typical of the 1930's era bridges. The toes of the East and the West bascule spans are supported by a center monolith, which separates the East and West sides of the canal. Each bascule span is approximately 30 m (98 ft – 6 in) long with a 9 m (29 ft) long roll. The fixed approach spans are 17 m (55 ft) and 11 m (35 ft) long each. The moveable and fixed approach spans have a span width of 9.45 m (31 ft). The bridge structure was designed for a Cooper E60 load rating.



Section on Center-Line of Bridge 6 – Looking South

The Bridge has been in operation for over 90 years without any comprehensive rehabilitation or upgrade projects. SLSMC completed a number of recent inspection and analysis studies on Bridge 6 to determine its residual life and to assess the most cost-effective method for securing the future operational safety and reliability of the bridge. The results of these studies are referred to as the "20/20 solution" and reflect an investment in excess of CDN $20M, for a life extension that will exceed 20 years. The Bridge 6 major rehabilitation project is currently under construction with approximately 50% of the work completed. The project is planned to be fully completed by mid- 2023.

Aerial View of Bridge 6 - East and West rolling spans - (looking South)

Aerial View of Bridge 6 - West fixed approach spans - (looking South)

Bridge 6 Background Timeline

Bridge 6 generally remains as fabricated and put into service in 1932. Over the years, there were a few minor rehabilitation and upgrade projects completed on the bridge. These projects are typically completed during the Welland Shipping Canal's non-navigation seasons during the months of January to March.

The projects completed between 1930's to 1970's focused mainly on structural upgrades to the rack frames, segmental girders and span stringers as well as restoration of the concrete counterweights. There were also some weld repairs done to the tread and track plate forgings. There are no records of any project work completed in the 1980's.

During the early 1990's, cracks have been identified in the segmental girder rolling tread plates at the tooth slots (pockets). This triggered an annual monitoring program of the tread and track plates segment cracks using NDE methods, initiated in the mid 1990's. Additional finite element analysis was completed with recommendations to install mechanical splints at all tooth slots where cracks have propagated from the slots to the adjacent bolt holes. This work has been completed between the late 1990's and into mid 2000's.

Segmental Girder flange reinforcing gussets (Left picture) and Tread Plate pocket mechanical splints (Right picture)

More recently, mechanical drive components, open gearing and the drive pinion racks have been refurbished in the early 2000's. Structural improvements have also been completed on the drive pinion rack support struts. New span lock mechanisms and hydraulic buffers have been installed in the late 2000's. New variable frequency drive induction motors have been installed in the mid 2010's. The motor brakes and machinery brakes still remain in use generally as originally supplied.

Bridge 6 mechanical drive refurbishment project in early 2000's

Due to Bridge 6 aging and the ongoing deterioration of vital structural and machinery components, SLSMC has recognized the need to complete additional pre-engineering work studies to develop an execution strategy for extending the useful life of the Bridge.

Bridge 6 Pre-Engineering Work

In 2004, SLSMC conducted an internal study to evaluate options for either restoring the existing bridge to prolong its life, or the construction of a new railway crossing of the Canal. Alternative solutions ranged from temporary repairs to a permanent solution with a new structure or re-routing of the rail line. For each option the study included details on the anticipated life increase, benefits, disadvantages, risks and budgetary life cycle cost analysis. The study identified the recommended option based on the lowest net present value: Major Repairs.

In 2006, SLSMC retained USACE to complete a Fatigue Life Study on all of Seaway's critical moveable assets. The study analysis included the following equipment: bascule railroad bridges (including Bridge 6), bascule road bridges, vertical lift bridges, miter gates and taintor gate valves. The study focused on the cyclic loadings causing stress variations in the moveable asset members which may result in fatigue and fracture. The study analyzed the effects of the cyclic loading on the assets to determine the potential failure caused by fatigue and fracture within the 50-year life span of the study which extends to the year 2060. The study found none of the Bridge 6 structural members (tread and track plate analysis were excluded in the analysis scope) will experience fatigue crack initiation within this lifespan based on the current vessel and train traffic volumes. However, a sensitivity analysis determined potential fatigue concerns, with crack initiation taking place within approximately 13-25 years based on increased vessel and train traffic volume scenarios.

In 2012, SLSMC retained Parsons-Brinckerhoff to conduct a Residual Life Study on Bridge 6. The scope of work included review of previous reports and drawings, arms length site inspections, mechanical and structural evaluations and recommendations on a maintenance approach plans with supporting cost

estimates including constructability commentary. The Residual Life Study maintenance plans recommendations were summarized into two categories: base (minor) maintenance and major (rehabilitation) maintenance.

Base maintenance items included work that can be performed in the near term without significant engineering or construction staging and had a total cost estimate ~$1.6M to keep the bridges serviceable through 2025. The main scope of work included: spot touch-up painting of floor beam flanges, installation of span lock cushion-locks, West span centering device corrections, track plate crack arrest work and other minor upgrades. This work was completed during non-navigation season 2015.

Major (Rehabilitation) Maintenance work items included work that will require engineering design, preparation of major contract documents and construction staging plans. The estimate cost of this work was $20M which would extend the serviceable life of the bridge for a minimum of additional 20 years. The main scope of work included: replacement of the tread and track plates, replacement of the drive machinery, full containment and painting of the structures, counterweight concrete repairs, monolith concrete wall re-facing and crack repairs, structural repairs, fixed approach span bearing plate replacement, span locks replacement, electrical and controls upgrades.

In 2018, SLSMC made the executive decision to proceed with the major rehabilitation of Bridge 6 recognizing that the asset is strategic to its operations to other external users like CN Rail. The results of the above studies are referred to as the 20/20 solution and reflect an investment in excess of CDN $20M, for a bridge life extension that will exceed 20 years.

Front End Planning

Recognizing the project is high value, high risk and critical to many users, the project work has been divided into several front-end planning phases to finalize the scope of work definition and the preferred execution approach. SLSMC also ensured early stakeholder (Canadian National Rail CNR) engagement throughout the entire front-end planning process:

- **Phase 1: Constructability Study** completed in 2018-2019 by Hardesty and Hanover (H&H) was to advance the major rehabilitation engineering work, participate in dialogue with CNR, determine and assess construction options which will consider CNR and SLSMC restrictions while meeting budget constraints established in preliminary cost estimates. Several constructability options were evaluated including SLSMC and CNR operations outages and durations impacts, costs, schedule, safety, environment, and several other evaluation impacts. Class 3 estimates and preliminary construction schedules were prepared for the preferred three options. Periodic workshop meetings were held between SLSMC, H&H and CNR to develop constructability study options and for CNR's input relating to rail operation requirements and maintenance constraints.

  The preferred construction option that was identified involved performing construction work over two years during SLSMC's navigation and non-navigation seasons. The main restrictions included non-interference with ship-navigation while limiting impacts to CNR operations. Each of the CNR rail tracks would be taken out of service each year for 6-months at a time (October to March) through a portion of SLSMC's navigation season and the entire non-navigation season.

This option also involved a 52-hr double track outage period each year to perform critical work relating to the replacement of the front segments of the tread and track plates.

Overall this option achieved the project objectives with the most reliable schedule and lowest construction costs. It also provided for limited impacts on rail traffic as no long-term rail closures were required and defined periods of single tracking could be used to satisfy CNR operations with a high degree of certainty.

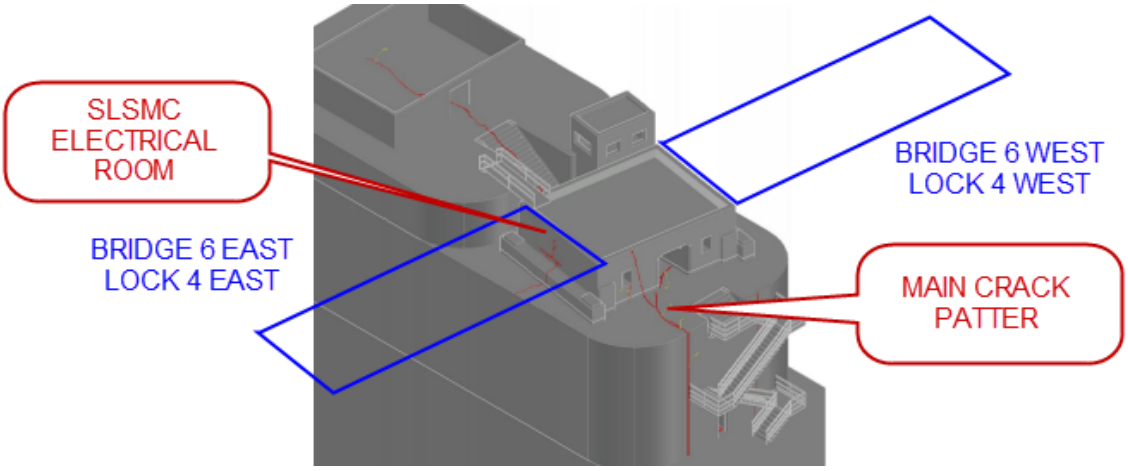
In parallel, SLSMC made an internal decision for the major rehabilitation project to be executed using the 'design-bid-build' delivery method rather than the 'design-build' method. This decision was based on the evaluation of several parameters such as the available project budget, availability of internal resources to support design work and to support construction execution, ownership risk exposure, available schedule period and familiarity with the different project delivery methods.

- **Phase 2b and 2c: Center Monolith Crack Investigation** study completed in 2019 including **Supplementary Geotechnical Investigation** work completed in early 2020, both studies by GHD consultants.

  The Bridge 6 rail tracks run East-West over the centre monolith and are supported by a concrete structure. The concrete monolith is an integral part of the railway support structure and is considered a static bridge. The rails are supported by a one-way concrete slab which is supported by two (2) interior load bearing walls which create the interior corridor, as well as two (2) exterior load bearing walls adjacent to the bridge nose bearings. These load bearing walls are in the North South direction. The slab is bound on the North and South sides by concrete walls which forms an electrical room used by SLSMC, accessible by a man door from the corridor.

  In 2009 wide cracks were noted in the floor and walls of the electrical room. The widths of the floor cracks ranged from 1.6 mm (0.0625 in) to 6.35 mm (0.25 in). Cracks were also visible on the soffit of the slab. The wide cracks on the North and South walls of the electrical room were visible from the exterior. Follow up checks in 2018 indicated wider crack widths up to approximately 18 mm (0.70 in) in width.

  The objective of this study was to review historical data, complete field investigations and data on the crack including crack measurements, crack monitoring, real time measurements under dynamic loading and crack mapping utilizing NDE methods with ground penetrating radar equipment. GHD were also tasked with creating a 3D model of the center monolith and surround structures and developing an FEA model to determine deformations and stresses under various loading conditions. Finally, GHD were to also determine the likely root cause of the crack and recommend the most effective repair option.



Indicative main crack patter on the Center Monolith

The Centre Monolith Crack Investigation Study evaluated the effect of operational loads on the structure to determine if a structural deficiency may have been the root cause of the crack. The monitoring of the crack movement throughout this study has revealed that the crack is an active crack and actively responds to the various load applications during the operational season and to temperature fluctuations during the non-operational season.

However, the Centre Monolith was found to be structurally adequate for resisting the operational loads of both the Welland Canal and the railway which crosses the canal on Bridge 6. Since the initial study concluded that the structural capacity of the Centre Monolith was sufficient to resist the applied loads and combinations thereof and that these loads or combinations of loads could not have caused such a wide crack, a supplementary Geotechnical Investigation that involved foundation bedrock coring and testing was undertaken to address possible foundation concerns underneath of Bridge 6 Centre Monolith.

Crack Meter installation inside the SLSMC Electrical Room
(total of 8 crack meters installed at various crack locations)

GHD conducted the Geotechnical Investigation in February 2020 (SLSMC non-navigation season with the canal drained) to confirm capacity and uniformity of the bedrock of Bridge 6 across the Centre Monolith and that there are no cavities present. Accordingly, six bedrock samples were taken (three at drained Lock 4 east and three at drained Lock 4 West lock floors adjacent to the center monolith) and tested for strength and quality and the FEA model updated with actual bedrock parameters. Based on the information collected in the supplementary investigations and the results of the updated structural analysis, the varying stiffness in the Centre Monolith foundation was eliminated as a potential cause of the investigated wide crack. Based on this, the likely possible root cause for the crack was freeze-thaw action of the rock-filled section of the center monolith, south of the area of concern. The crack movement measurements to the south of the bridge centerline were observed to be more severe, indicating that the southern section of the monolith is weaker than the north, suggesting that the crack may have originated in that section.

Hoisting of drill rig using 80T crane North of Bridge 6 West

Borehole drilling at floor of Lock 4 East adjacent to Center Monolith (West similar on opposite side)

The studies concluded that current crack movements are within acceptable range and there is no need for immediate repairs at this time. Risk of large crack movement growth is low, even though it is active. It was therefore concluded that SLSMC can proceed with the major rehabilitation detailed engineering phase. SLSMC's infrastructure group are continuing to monitor the crack movement on an ongoing basis and collecting crack movement data against detailed criteria based on cumulative readings and combined loading effects (operational, thermal, etc) which would alert SLSMC to initiate further investigation and/or repairs. Consideration is given to prepare detailed plans for crack repairs to limit the crack from widening further which would be executed following completion of Bridge 6 Major Rehabilitation works.

- **Phase 3: Detailed Design Engineering** completed between 2019 and 2020 by Hardesty and Hanover (H&H). The key project objectives were to increase the useful life of the bridge until 2045, maintain minimum structural integrity of the bridge and increase the reliability of the bridge by completing civil, structural, mechanical and electrical and controls upgrades within specified schedules while non-interfering with navigation traffic and minimizing impacts on rail operations.

  The consultant was tasked with the following work:

  1. Data collection
  2. Detailed site inspections and surveys including baseline strain gauge testing of the balance of each span
  3. Detailed design of the major rehabilitation items including fabrication and construction drawing package, technical specifications, railway closure plans and suggested construction schedules
  4. Cost estimate updates for SLSMC
  5. Technical services during tendering and construction to support SLSMC.

  The Detailed Design deliverable documents were prepared for use by CNR for the review and acceptance of the project; for use by the Contractor to execute the major rehabilitation construction works, installation of equipment, testing and commissioning; and for use by the Owner and Owner Representatives for inspection and final acceptance of the work. The final deliverables were completed during winter of 2020 in time to issue major rehabilitation construction and gearbox procurement tender packages.

  The front-end planning work required extensive collaboration between SLSMC, CNR and H&H. Seventeen working meeting sessions were held throughout this phase of the project. CNR involvement included technical document and schedule reviews as well as agreements with SLSMC on the flagging and rail track shut-down requirements.

- **Phase 4: Contractor Pre-Qualifications and Expressions of Interest** completed during 2020 by SLSMC. SLSMC have reached out to over twenty local and multi-national contractors to determine their capacity, skill, expertise and interest in bidding on the Bridge 6 Major Rehabilitation works. The process involved in-person meetings as well as formal Request for Qualification and Expression of Interest submittals including conducting previous project reference checks. The final list of tenderers was narrowed down to seven bidders.

  SLSMC completed a similar pre-qualification process for the vendors bidding on the supply of enclosed gear boxes. The gearboxes were identified as critical long-lead items on the project to be free issued by SLSMC to the major rehabilitation contractor.

Bridge 6 Major Rehabilitation Construction and Procurement Tendering

The Bridge 6 Major Rehabilitation Construction tender was initially issued to the bidders in January-2020 with a planned closing in March-2020, the closing later extended to April-2020 on the request of the bidders. The tender closing coincided with the onset of the global Covid-19 pandemic. The uncertainties due to the unfolding pandemic was one of the main reasons why only two bids have been received and the bids submitted were much higher than estimated (~160%). The other reason for the high bids as stated by the contractors were the liquidated damages provisions required to complete the contract.

In parallel, SLSMC tendered a procurement contract for the fabrication and supply of two sets of enclosed gearbox reducers for Bridge 6 East and West machinery rooms which were long lead delivery items. The gearboxes had a delivery timeframe of approximately 9-months which would coincide with the anticipated start of major rehabilitation construction work during the non-navigation season of winter 2021. The award of the contract to the low bidder (Power Engineering and Manufacturing Ltd from Iowa, US) required additional changes related to the onset of Covid-19 pandemic.

In May-2020, due to budgetary limitations SLSMC issued cancellation letters to the major rehabilitation construction bidders. Internal meetings were held to determine how best to continue with the advancement of the major rehabilitation project. A strategic decision was made to re-tender all the work but to separate out portion of the civil work into a separate contract for an earlier execution and to re-tender the Bridge 6 major rehabilitation work with reduced scope of work with a delayed execution schedule. This approach would allow to complete lower risk work earlier while pushing out more critical work and long lead delivery supply by a year. H&H were retained to prepare an updated set of technical plans for re-tender as follows:

- Bridge 6 – Lock 4 Center Monolith High Wall Re-facing contract planned for execution during non-navigation season winter of 2021. The scope of work involved the demolishing of the concrete of the center monolith wall facing and adjacent coping (South of Bridge 6 East and West), installation of steel anchors and reinforcing steel and placing of cast-in-place concrete to the original lines and grades according to the specified plans. The tender closed Sep-2020 with six bids received. The low bid was within the engineer's cost estimate certainty and was awarded to Rankin Construction in Oct-2020 ahead of winter works 2021.

- Bridge 6 – Major Rehabilitation Construction planned for execution from 2021 until 2023. The scope of work covered the East and West moveable spans as well as the fixed approach spans, including mechanical, civil, structural and electrical upgrades. The scope of work would include:

    1. Machinery room rehabilitations;
    2. Span drive machinery rehabilitations;
    3. Span lock machinery rehabilitations;
    4. Span buffers replacements;
    5. Tread and track plate replacements;
    6. Structural rehabilitations;
    7. Concrete repairs to the counterweights;
    8. Concrete repairs at the fixed approach spans and monoliths;
    9. Bearing replacement of the fixed approac spans;
    10. Festoon system replacements;
    11. Electrical upgrades related to the machinery rehabilitations;
    12. Lighting upgrades;
    13. Testing and commissioning;
    14. Supply of critical spare parts.

The bidders had to ensure the work could be completed to meet all key restrictions and milestones based on portions of the rehabilitation work completed between train traffic during 'natural windows', during 'single track closure' periods, during 'double track closure' periods, during the Navigation Seasons and portions of the rehabilitation work completed during the Non-Navigation Seasons with no interference to vessel traffic and minimal disruptions to CNR operations.

The tender closed Sep-2020 with two bids received. The low bid was below the engineer's cost estimate. This could be explained by lower worksite organization costs due to removed liquidated damages clauses, lower civil costs due to familiarity of the work by the selected sub-contractor (Rankin) and compared to the original tender closing in March-2020, which coincided with the COVID-19 initial outbreak. The bidders were now able to obtain multiple more competitive sub-contractor prices. Pre-award meetings were held with the low bidder in Nov-2020 to review the bid meets all the technical and commercial requirements. The Bridge 6 Major Rehabilitation Construction contract was finally awarded to Kenaidan Contracting Ltd (KCL) in Dec-2020.

Bridge 6 Enclosed Gearbox Supply - Execution

The Procurement contract for the fabrication and supply of enclosed gearboxes was awarded to Power Engineering and Manufacturing Ltd (PEM) in April-2020. The contract included the supply of two sets of gearboxes – one set for Bridge 6 East and another for Bridge 6 West. Each set included a primary gearbox reducer and two secondary reducers with torque arms.

The primary reducers are custom horizontal parallel shaft units with solid output shafts. The design included special double extended input and output shafts for the coupling of existing motors and to accommodate the installation of new machinery brakes. The units have a 150HP input rating at 352 RPM (13.4 in-kip at each input shaft) and 475 in-kip output torque rating at 20 RPM with a service factor of 1.0.

The secondary reducers are custom shaft mounted single reduction reducers with a custom torque arm. They have a hollow hub at the low speed shaft for a shaft mounted arrangement, with the hub of the low speed gear secured to the main pin pinion shaft in the field using a shrink disc. The units had to be designed with certain dimensional constraints to allow for installation between existing structural members on the machinery room that would not be replaced as part of major rehabilitation work. The units have a single input shaft rated for 285 in-kip torque at 20 RPM and 1,050 in-kip output torque rating at 5.4 RPM with a service factor of 1.0.

SLSMC and H&H were involved throughout the entire design, fabrication and testing process. H&H were responsible for the technical review of all designs, calculations, material, quality control and testing report submittals. The fabrication schedule had to be extended due to PEM's staffing impact from Covid-19. With this in mind, SLSMC decided to complete all factory acceptance testing remotely via live video conference. Each gearbox had to complete a static 'no leak' test and a set of dynamic tests under 'no load - full operating speed' and 'full load - full operating speed'. Each dynamic test was to be for a minimum duration of 1 hour in each direction.

The ‘no leak’ test was completed using low pressure air with a pressure regulator, tested between 8-10 psi. Each gearbox was tested to hold the air pressure for a minimum of 20 minutes and documented using a pressure gauge.

The dynamic testing involved a custom setup which allowed testing all the gearboxes in tandem at once rather than individually. This setup significantly reduced the overall time needed to test all the gearboxes. An electric motor was used to drive the primary gearbox with a torque meter and torque limiting clutch mounted between them. The primary unit output was connected to the two secondary gearbox inputs, which were coupled to the two additional secondary gearbox outputs. Those secondary unit inputs were then connected back to the second primary unit input and finally a hydraulic pump was connected to the primary unit’s input shaft. The pump was used to apply load to the output of the stand with an adjacent cooling unit to ensure pump oil temperature remained low enough for the duration of the tests.

Enclosed Gearbox Factory Acceptance Testing with the units connected in tandem
Dynamic tests witnessed remotely via video conference

Live measurements were taken and recorded of the temperatures (ambient, oil, shaft bearings), noise levels, shaft speeds and transferred torque. Post test inspections were also completed on all the units to ensure acceptable tooth contact patterns. The remote video conference was set up using up to four cameras at a time: torque meter and tachometer readouts, roving temperature monitor, elevated view of the overall test stand and a roving sound level monitor.

The gearboxes were delivered to SLSMC in March-2021, approximately one year after the award of the contract to PEM. Upon receipt of the gearboxes each unit was inspected, filled with filtered oil and placed into long-term storage at a local vendor machine shop until needed by the major rehabilitation contractor for installation.

Enclosed Gearboxes – in long term storage

Bridge 6 Major Rehabilitation Center Monolith Wall Re-Facing Execution

The construction contract for the major rehabilitation of the center monolith wall was awarded to Rankin Construction Incorporated (RCI) in October-2020. The project scope included concrete re-facing of the high wall and portions of the coping surface at the center wall of Lock 4 – Monolith 3C, just north of Bridge 6 East and West. The work was executed during the non-navigation season winter of 2021 using day and night crews working Monday to Friday.

Bailey bridge connecting Lower Lock 4 East with the center wall bullnose
Concrete pour at the center monolith wall

Bridge 6 Major Rehabilitation Construction Execution – Early Works

The major rehabilitation contractor KCL made a request to SLSMC to advance the fixed approach span concrete repairs in the spring and summer of 2021, ahead of the original start planned for the fall of 2021. This request would take advantage of RCI (civil sub-contractor to KCL) being already mobilized nearby following the completion of the winter works Bridge 6 center monolith wall refacing work. It would allow the contractor to advance non-critical work in non-restricted areas during navigation season and allow further scoping and site preparation opportunities such as installation of temporary platforms and span jacking brackets ahead of the more critical work.

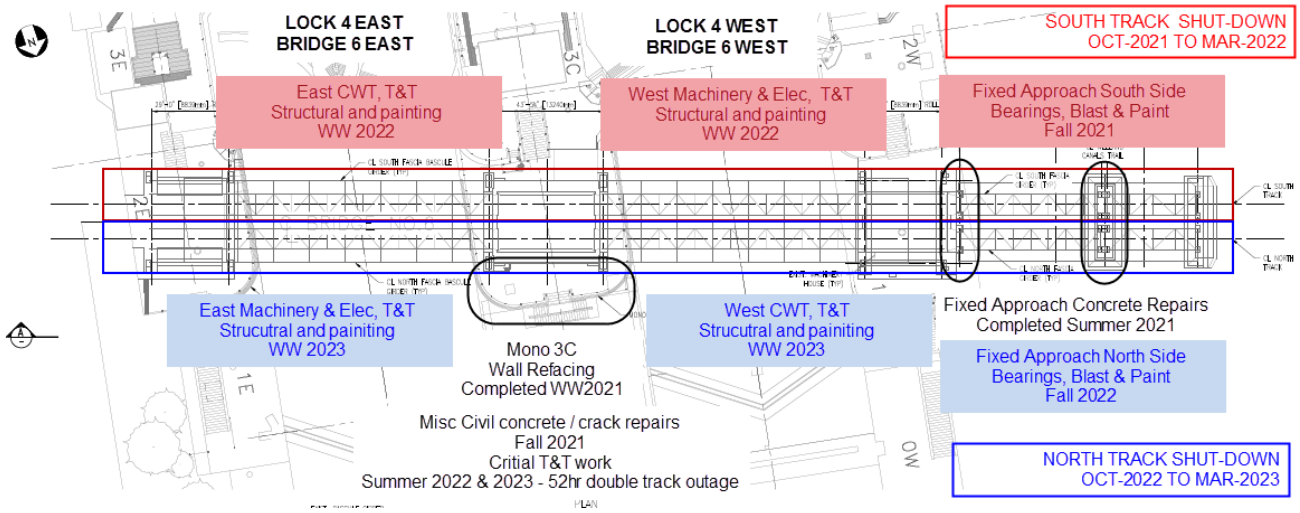
Fixed Approach Spans Center Pier Rehabilitation – southbound lane and trail closed
Reinforcing steel and anchors installed, formwork in progress

Fixed Approach Spans Center Pier Rehabilitation completed – southbound lane re-opened

The center pier and East abutment concrete repairs were completed by July 2021. KCL and RCI returned to the work site in September 2021 to complete the West abutment repairs in time for the jacking of the South fixed spans and bearing replacement scheduled for October.

Bridge 6 Major Rehabilitation Construction Execution

The major rehabilitation construction contract is complex, involving multiple stakeholders and multiple discipline work to be completed over a duration of more than two years. All the stakeholders involved recognized the importance of close co-operation and co-ordination to complete the project safely with minimal delays to SLSMC and CNR operations. The planning, sequencing and site co-ordination remains very critical to ensuring all the work could advance safely and efficiently as different site challenges presented themselves throughout the project.



Bridge 6 Major Rehabilitation Construction Sequencing of Major Phases of Work

Fall 2021 – Navigation Season Fixed Approach Span and Preparation Works (South rail track closure)

This work coincided with CNR's south track shutdown between October 2021 until March 2022. The major scope of work involved sequentially jacking the South 55' fixed span followed by the 35' fixed span, removal of existing bearings and replacement with new bearings. Following the replacement of the bearings on each span, RCI moved on to the repair of the concrete cracks at Bridge 6 East and West areas inside the Lock structures ahead of the winter works, while scaffolding was installed below each fixed span including a full enclosure to allow abrasive blasting and painting of the span structure to begin. The work was completed on day shifts, five days a week to coincide with the availability of CN flagging services.

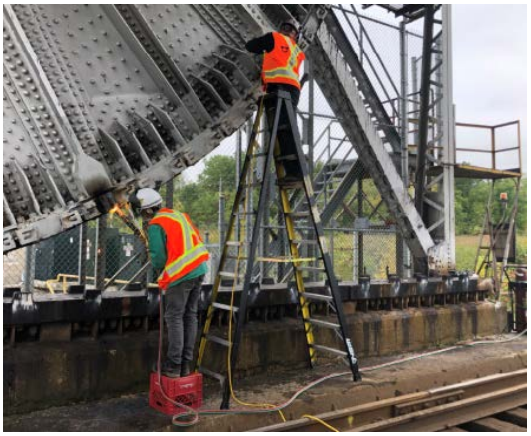
The existing paint contains lead so special precautions were in place to ensure safe execution of work. The Contractor was responsible for obtaining all necessary permits for roadway and pedestrian trail closures. The Contractor also took advantage of the South track closure to advance preparation works on

the East and West moveable spans related to the replacement of the machinery rooms and the tread and track plates.

Installation of scaffolding on the South 55' span for painting work access

South 35' span jacking for the replacement of the bearing plates

Early removal of existing blast plates below machinery rooms



Removal of tread plate mechanical splints and perimeter welds

Winter 2022 – Non-Navigation Season Moveable Span Works (East and West) (South rail track closure)

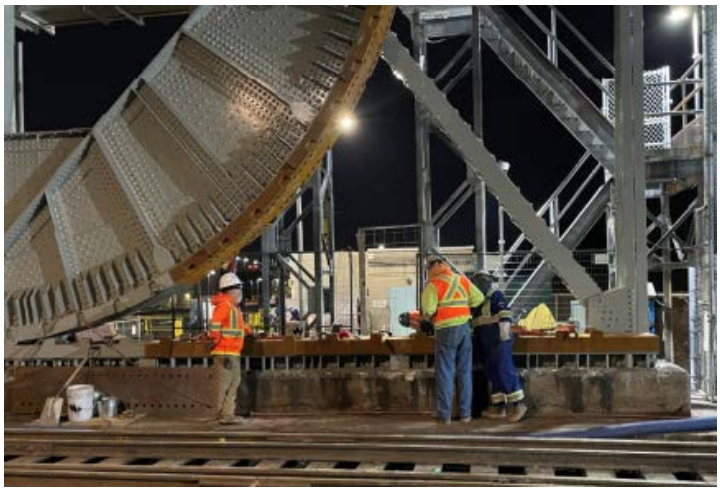
This work was planned around SLSMC's early shutdown of the West flight locks on 1-Jan-2022 while the East flight locks remained operations until 8-Jan-200. The canal re-opened on 25-Mar-2022 on the East side while the West side opening was delayed until 31-Mar to provide the Contractor with longer work windows. The early shutdown and late opening of the flight locks had to be co-ordinated between the project team and SLSMC operations group to ensure timely notice to the shipping vessel Clients. CNR's south track shutdown was in place until March 2022. The work was executed on a 24/6 basis with the 7th day a week being available to recover any schedule slippage.

The major scope of work involved replacement of the South middle and back tread and track plate segments, machinery replacements, counterweight concrete rehabilitation and painting of the south side of

the spans. Changes to the sequencing of work were required due to delivery delays of machinery components including span drive motor and machinery brakes, span drive pinion forgings and span lock actuators. Therefore, the machinery room and span drive replacement planned on the West side for winter 2022 had to be postponed. The Contractor opted to complete counterweight refacing on the west span in lieu of the planned west machinery replacement.

Bridge 6 West – Scaffolding and Enclosure installed for painting and counterweight re-facing
Bridge 6 East – Scaffolding installation in progress - (looking North)

Installation of new middle and back tread



Track plate segments (South) West span shown, East side similar

June 2022 – Navigation Season South Front Tread and Track Plate Segment Replacement (North and South rail track closure – 52hr critical work window)

This phase of the work involves a critical CNR double track closure for a continuous window duration of 52-hours. This is to allow the replacement of the existing front segments of the rolling tread and track plates with the spans fully raised. This constraint influenced H&H's design approach to replace the

components in-kind with limited modification and to focus on pre-closure fabrication and testing to limit the work required during the outage. The execution of the work once again required very close co-ordination and planning between all stakeholders. A detailed 52-hr critical path schedule was prepared to identify all the work tasks, tools and equipment needed to complete the work.

Installation of new front tread

Track plate segments (South) East span shown – raised - West side similar

The 52hr window also allowed finishing remaining concrete repairs on the East monolith behind the heel floor beam of Bridge 6 East which is only accessible with the span fully raised.

Preparations for the concrete repairs of the East Monolith
Bridge 6 East raised, existing front tread and track plate segment removal in progress

Fall 2022 – Navigation Season Fixed Approach Span and Preparation Works (North rail track closure)

The scope of work for this phase of work is similar to the Fall 2021 South fixed approach span work, except the work in Fall 2022 will be completed on the North spans. Some of the temporary access platforms from 2021 remained in place and will be re-used this fall to shorten the mobilization period to start the work.

Winter 2023 – Non-Navigation Season Moveable Span Works (East and West) (North rail track closure)

As previously mentioned, there were delays in the supply of some of the mechanical equipment and the Contractor had to change the sequence of the work. All the refacing work of the concrete counterweights was completed Winter of 2022 however all of the machinery refurbishment work is still outstanding.

SLSMC are currently evaluating options to complete the remaining work over one or two winter shutdowns.

Project Facts

1. Most complex and highest cost project undertaken by SLSMC in the recent past.

2. Eight (8) Contracts awarded in total:
    a. Constructability Study
    b. Crack Investigation Study
    c. Detailed Engineering
    d. Center Monolith Wall Re-Facing
    e. Procurement of Gearboxes
    f. Major Rehabilitation Construction
    g. Fibre-optic Line Installation
    h. Coating Inspection Services

Bridge 6 Major Rehabilitation Construction - Key Players and Stakeholders

Entity	Abbreviation	Project Role
The St. Lawrence Seaway Management Corporation	SLSMC, Seaway	OWNER
Hardesty & Hanover LLC [Hatch]	H&H, HH [HATCH]	ENGINEERS OF RECORD / OWNER'S REPRESENTATIVE
Canadian National Railway	CN, CNR	KEY STAKEHOLDER
Kenaidan Contracting Ltd.	KEN, KCL	GENERAL CONTRACTOR
Rankin Construction	RCI	CIVIL SUB
WSN Nicholls	WSN	MECHANICAL SUB
Procon	PRO	ELECTRICAL SUB
Dayson	DAY	COATING SUB
Wiss-Janney-Elstner	WJE	CONTRACTOR's MOVABLE BRIDGE CONSULTANT