# Rehabilitation of the Red River Bridge on PR 305

Rhys Laffin
Bridge Designer
Tetra Tech Canada Inc.
Winnipeg, Manitoba
rhys.laffin@tetratech.com

Evangeline Murison, M.Sc., P.Eng.
Bridge Management Services Engineer
Manitoba Transportation & Infrastructure
Winnipeg, MB
evangeline.murison@gov.mb.ca

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## Abstract

The major rehabilitation of the Red River Bridge on PR 305 included replacing the existing superstructure with a wider deck to accommodate pedestrians and increased traffic volumes. Strengthening and widening of the existing concrete substructures and foundations were performed to carry a new steel plate I-girder and CIP concrete deck. The continuity of the original bridge was altered and the existing abutments were modified to be semi-integral type to reduce the number of bridge expansion joints. The bridge construction staging maintained a single operating lane of traffic throughout construction.

## Background

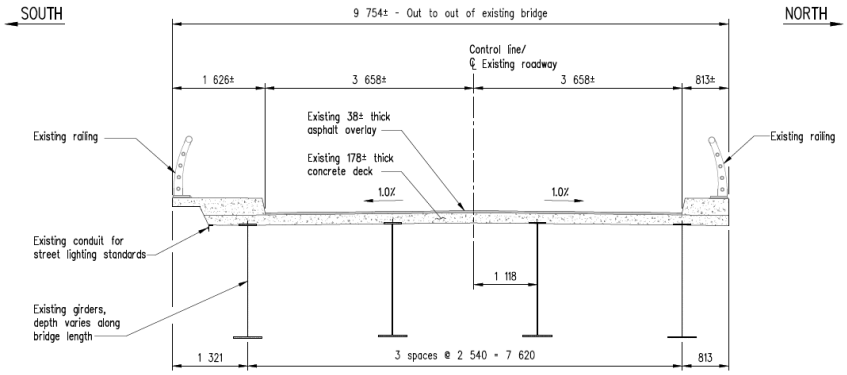
### Introduction

The original bridge on Provincial Roadway (PR) 305 over the Red River, also referred to as the Louis Riel Bridge, is located in the Rural Municipality of Ritchot, immediately east of Ste. Agathe, MB.

The original structure was a 243.8m, nine-span, steel I-girder structure originally constructed in 1959, supporting an AADT of 2380 with 11.13% truck traffic. The structure, originally designed for HS20 design vehicle loading, two lanes of traffic and consisted of a reinforced concrete deck supported by four lines of steel I-girders. The I-girders used pin and hanger connections to provide continuity for live load and

varied in depth dependent on the span lengths. The girders were supported by reinforced concrete substructures founded on concrete caissons at the abutments and land piers and on spread footings at the river piers.

Figure 1. Original Bridge Cross Section




*Source: Tetra Tech*

## The Project

The rehabilitation is expected to extend the structure's service life by an additional 50 years. The work included replacing the original superstructure with new, steel plate I-girders and a widened CIP concrete deck. Included in the widened bridge were two (2) 3.7m wide traffic lanes with 1.8m shoulders, and a 2.7m wide AT pathway separated from traffic by a CIP concrete barrier. Modifications to the existing substructures, including widening and strengthening, were also performed to carry the increased live load and widened superstructure. The continuity of the bridge superstructure was changed to reduce the number of expansion joints on the bridge and incorporate the use of semi-integral abutments. New steel-reinforced elastomeric bearings were installed at all substructures. Utilities on the new structure includes navigation lighting for the Red River, combination AT pathway and bridge overhead lighting, underbridge lighting for the river-side pathway that runs below the bridge near the west abutment, and a spare conduit for potential future utilities. Various approach roadwork improvements were made to address safety concerns with traffic entering the town of Ste. Agathe.

## Project Team

Tetra Tech Canada Inc. (Tetra Tech) was the prime consultant for the assignment. The extended project team included:

- Lawson Consulting & Surveying Ltd. (DD Survey)
- TREK (Geotechnical and Hydraulics)
- AAE Tech Services Inc. (Environmental)

## Detailed Design

As a major rehabilitation, the project had certain limitations and constraints the design team needed to consider and incorporate into the final design. The main challenge being the re-use of the existing substructure and foundations. This not only dictated the girder design and span arrangements, but also the bridge depth and vertical profile, to limit extent of the approach road works as much as possible. The project terms required that the bridge be designed for an increase in design live load; the original was designed for the HS 20-44 and the new was designed for the maximum effects of the AASHTO design truck (HL-93) and MTI's prescribed vehicles (HSS 25 truck and HS 30 Lane Load).

Considering the importance of the river crossing to local and provincial travel and the large distance for a route detour, maintaining traffic through construction was required. The width of the Red River at the bridge width was too extensive for consideration of a temporary ACROW structure, so the rehabilitation needed to be undertaken with traffic management considerations.

### Construction Staging

Maintaining one lane of traffic throughout construction was critical to the success of the project. A construction schedule was developed in five (5) stages as follows:

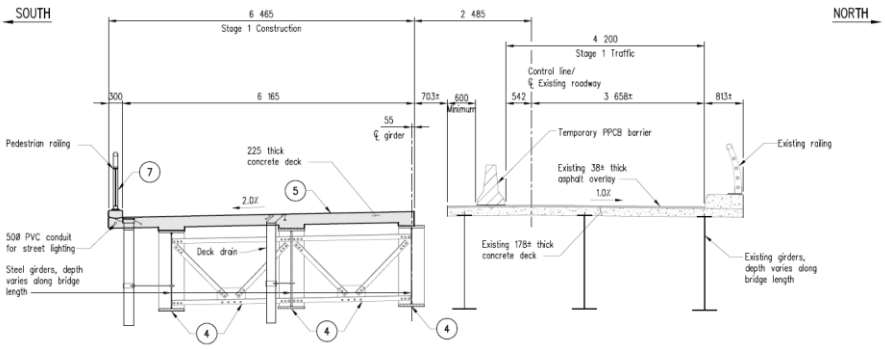
- Substructure Modifications – the major modifications to the substructures (including additional caissons and pier bent beams) were detailed to be constructable while maintaining all existing traffic on the original bridge
- Stage 1A – crash attenuation units were installed on the end of the bridge newel posts at both ends to protect traffic during construction
- Stage 1 – a portion of the original bridge was demolished (1 girder line and deck). Single lane of traffic was kept on original bridge (3 girder lines). Three new girder lines and deck were constructed.
- Stage 2 – Single lane of traffic was moved to new bridge and original bridge superstructure was fully demolished. Remaining new girder lines and concrete deck were constructed. The middle bay of intermediate steel diaphragms were installed between Stage 2 deck pour and the stitch slab pour. North travel lane was paved with final asphalt deck surface.
- Stage 3 – Single lane of traffic was moved to the completed section of the new bridge (from Stage 2). Concrete barrier separating traffic lanes and AT path were constructed, and remaining deck was asphalted.

MTI installed and maintained timed traffic signal lights for the alternating single traffic lane throughout the duration of the project. The single traffic lane and construction activities were separated by temporary portable precast e concrete traffic barriers (PPCB) with a minimum of 600mm clear zone for deflection behind the temporary barriers.

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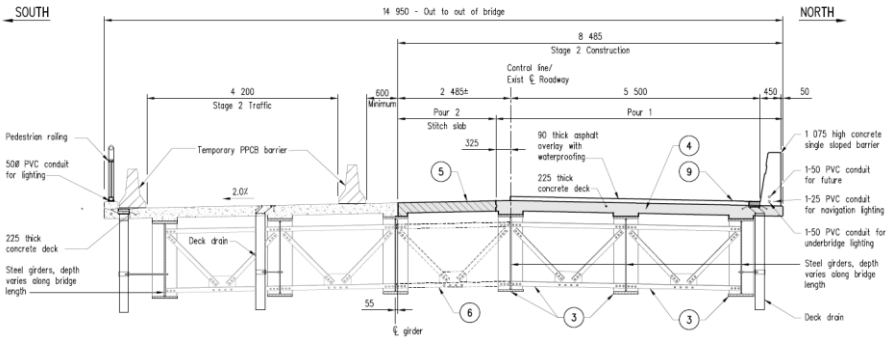
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Figure 2. Stage 1 Construction



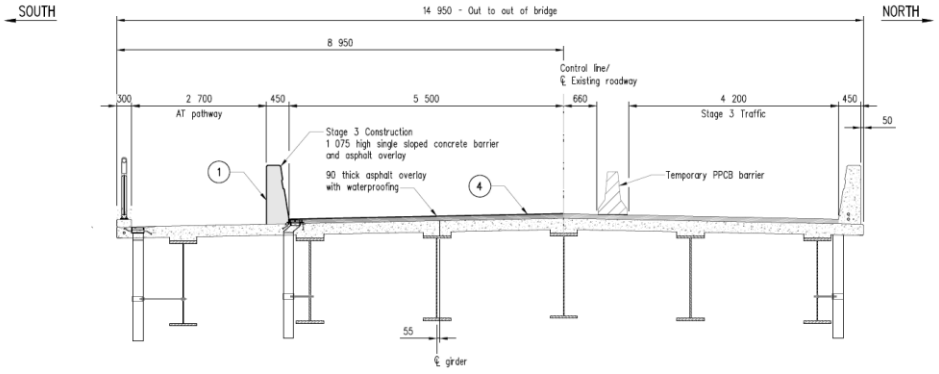

*Source: Tetra Tech*

Figure 3. Stage 2 Construction




*Source: Tetra Tech*

Figure 4. Stage 3 Construction

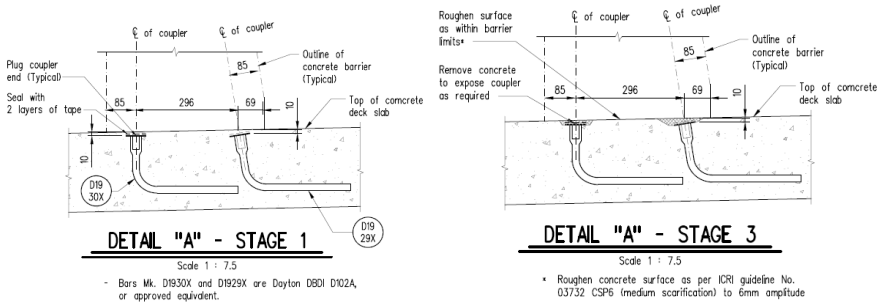



*Source: Tetra Tech*

The construction of the concrete deck included a 2.5m wide "stitch slab" between the major deck stages. The stitch slab was included to allow for the differential and independent deflection of the steel girder staged construction to more accurately assess the girder elevations and concrete deck haunch heights. The tender also included provisions that the middle bay of intermediate diaphragms (between Stage 1 and Stage 2 girders) were to be field drilled.

One challenge with the staged construction was that traffic would need to use the portion of the bridge specified for the AT pathway. The final cross-section has a CIP concrete barrier separating the traffic lanes from the pathway. To permit the use of the full deck width for traffic during construction, bent threaded rebar couplers were specified to be cast into the deck. These couplers were buried 10mm beneath the top of the deck surface, and the ends were sealed. This allowed for traffic to drive over the location of the barrier during Stage 2. Once traffic was shifted, the couplers will be uncovered, and vertical barrier reinforcement will be threaded into the couplers prior to casting the barriers. Threaded couplers were also used along the length of the bridge deck for the transverse deck reinforcement due to the their being insufficient distance during the staged construction for proper reinforcing lap lengths and construction clearances.

Figure 5. Barrier Reinforcing Couplers




*Source: Tetra Tech*

Similarly, modifications to MTI's standard steel deck drain details were made to allow for the installation of the drains prior to the completion of the bridge paving operations. Drains were detailed with a field-welded extension to allow the main section to be cast flush with the surface of the deck concrete allowing for traffic during construction staging, including snow-clearing operations. Prior to bridge paving, the extensions were installed to bring the deck drain grate level with the bridge deck asphalt.

## Substructures and Foundations

Since the proposed bridge cross-section was wider than the original, the existing substructures needed to be modified to carry both a higher than originally prescribed live load and additional girder lines. All original caissons were 762mm diameter shafts with the pier caissons having a 1212mm diameter bell at the bottom. New end-bearing concrete caissons were drilled approximately 2-3m deeper than the existing caissons into the silt till. New caissons were straight shaft (no bell) with varied diameters of 760mm for the abutments and 1200mm and 1500mm for the piers.

The original structure had four different substructure types:

- Abutments – standard stem-wall abutments founded on caissons
- River Piers – monolithic concrete pier shafts supported on shallow footings founded on the till layer in the channel
- Pier Bents SU2, SU8, and SU9 – four caissons supported on a 900mm deep CIP concrete beam
- Pier Bents SU3 and SU7 - 1.8m deep CIP concrete beam was supported by two 1.07m diameter concrete columns. Each column was attached to a concrete footing that was supported by either three or four concrete caissons

Each substructure type required a different and unique strengthening and widening design solution.

Abutments were widened by demolishing the existing wingwalls and constructing footing extensions and new wingwalls, supported on new 760mm diameter caissons.

Existing land pier bents SU2, SU8, and SU9 were strengthened by constructing new caissons to the outside of the existing pier and connecting the original to the new with a deeper, wider pier bent beam.

New caissons at Pier SU2 were increased in diameter to 1500mm to account for the change in bridge continuity by eliminating the original girder hanger. New caissons at piers SU8 and SU9 were increased to 1200mm diameter.

Land pier bents SU3 and SU7 included constructing new concrete columns supported on new footings and new caissons outside the footprint of the original. New columns and footings were tied to the original with CIP concrete tie-beams.

The rivers piers, SU4, SU5 and SU6, were strengthened to carry the additional width by constructing a 3m deep extension to the hammer head style bearing seat. This beam cantilevered off each end to support the additional girder lines. The effects of the eccentric loads were checked against the bearing capacity of the existing shallow foundation footing bearing on till within the channel.

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The pier bents were modelled to determine the load sharing between the existing and new caisson deep foundations. New caissons were larger and deeper than the existing and therefore developed more geotechnical capacity. Based on the construction staging, the existing caissons were needed to carry only the weight of the existing substructure by themselves. Once new foundations were tied into the existing, the system worked as a whole, distributing the load across all foundations. The new bearing seats and beams were made integral with the existing through shear transfer using concrete roughness and dowels drilled and grouted into the existing concrete.

Major substructure work was designed and detailed to be constructed prior to any additional work being performed on the bridge, allowing for substructure modifications to be completed prior to bridge staging and demolition. This allowed for un-interrupted traffic to remain on the bridge and also allowed for an earlier construction starting date.

## Girders and Bridge Continuity

In order to maintain the existing top elevations of the substructure bearing seats and to avoid excessive raising of the bridge profile to avoid additional approach roadworks, varying girder depths were utilized to mimic the original condition.

The original steel girders had three (3) depths as summarized below:

Table 1. Original Girder Details

| Location | Girder Type 1 | Girder Type 2 | Connection Details |
|---|---|---|---|
| Pier SU2 | 33 WF 130 | Welded plate girder, 1450mm deep web with varying flange thicknesses | 75mm diameter steel pin |
| Pier SU3 | Welded plate girder, 1450mm deep web with varying flange thicknesses | Welded plate girder, 1960mm deep web with varying flange thicknesses | Pin-hanger joint, smaller girder type hung from larger |
| Pier SU7 | Welded plate girder, 1960mm deep web with varying flange thicknesses | 30 WF 108 | Pin-hanger joint, smaller girder type hung from larger |

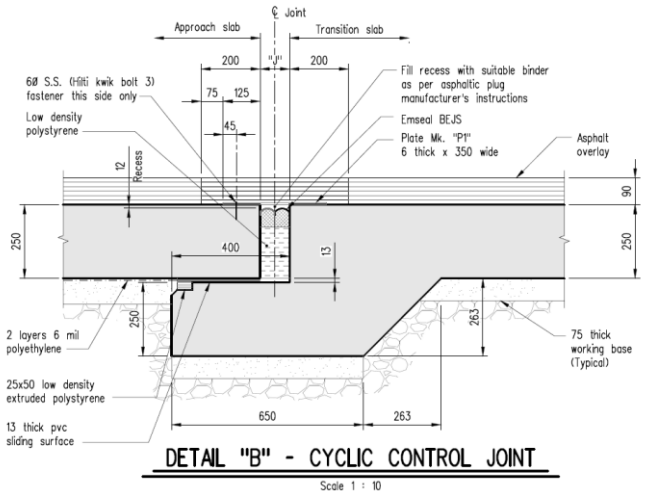
Due to the overall length of the bridge, and the need to vary the girder depth, making the full bridge semi-integral was not feasible. Instead, the bridge was separated into three distinct sections, which were all designed as continuous over interior supports:

- West Spans – SU1 to SU3 (continuous at SU2)
- River Spans – SU3 to SU7 (continuous at SU4, SU5, and SU6)
- East Spans – SU7 to SU10 (continuous at SU8 and SU9)

Girders in the west spans tapered linearly from 630mm deep at SU1 to 1280mm deep at Pier SU2. The river span girders were a constant depth of 1700mm and the east spans a constant depth of 575mm. Due to the shallow depth of the girders in the West Spans and the East Spans, K-bracing intermediate diaphragms were not sufficient to carry the rotation construction loads from the deck overhang formwork, screed, and moveable bridge hoarding. Full depth W-beam diaphragms were designed to resist these loads, allowing for standard bridge construction practices by the Contractor.

The original bridge had bridge expansion joints at the following substructure locations – SU1, SU4, SU5, SU6, and SU10, with pin-hangers and deck joints at SU2, SU3, and SU7. The new bridge configuration has semi-integral abutments and new strip seal (EFE-400) deck joints only at piers SU3 and SU7, which will greatly increase the longevity of the structure and reduce the anticipated maintenance. The bearing seats at piers SU3 and SU7 were modified to include a raised reinforced concrete pedestals to account for the difference in girder depths at the bearing locations. At the ends of the bridge approach slabs, cyclic concrete joints allowed for movement of the approach slab. A transition slab with a drop beam supported the free end of the approach slab and the Asphaltic Plug Joint (AIFB).

Figure 6. Cyclic Control Joint




*Source: Tetra Tech*

## Surrounding Area Improvements

Included in the bridge rehabilitation were improvements to the approach roadworks and surrounding green spaces, most noticeably on the west end of the bridge into Ste. Agathe. Through discussions with MTI, the Region, and local residents, it was determined that right-turning movements east onto the bridge from northbound Pacific Ave. were difficult with the original road configuration, especially for large vehicles like trucks or farm equipment. A separate right turning lane, with a turning radius designed to accommodate the WB-20 and a raised concrete island were included to address this issue. Additionally, both the south-west and north-west edges of the bridge were flared outwards from the bridge centerline to provide better sightlines for the intersection of PR 305 and Pacific Ave.

Concrete drainage chutes were added at the four corners of the bridge to handle runoff from the bridge and to prevent erosion to the bridge embankments. A new AT path was designed to connect the bridge to the existing paths on the southwest bridge corner.

Several discussions with MTI occurred regarding traffic calming for vehicles heading west over the bridge as they approach Ste. Agathe. There was concern with the speed of traffic as it crossed the bridge and the proximity of the school on the west side of the bridge.

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Several traffic calming options, including physical alterations such as horizontal deflection, rumble strips, curb extension/narrowing, and visual pavement marking were discussed. However, since the traffic calming would occur within the limits for the bridge the physical alterations were considered impractical and the visual would not be effective during the winter due to snow coverage. The final solution was to include a bridge mounted speed display device to alert drivers of their speed as they crest the bridge and approach the town. This, with the improvements to the intersection, including the right-turning lane and increased sightlines, were considered sufficient for this location and specific situation.

## Environmental

One challenging aspect of the project was receiving DFO authorization for the construction plans. Assessment of the aquatic habitat identified both live and remnant shells of Mapleleaf Mussel, Quadrula quadrula, downstream of the site. While the project did not require any additional permanent structures within the watercourse, construction activities would require temporary disturbance of portions of the instream channel and erosion protection in the form of rock riprap could potentially affect the channel embankments. This was identified as a potential risk at the site of being buried by disturbed sediment or lethal damage from the installed of the access pads to Mapleleaf Mussel and other mussel species.

To mitigate this risk, a mussel salvage operation was undertaken in September 2022, where divers thoroughly searched the channel bottom within the affected area. Mussels collected during the salvage were to be identified, categorized, and relocated upstream of the site. No mussels were detected within the proposed construction zone during the salvage.

Although no mussels were found during salvage, DFO still assessed the bridge site as a habitat for mussels. In order to receive DFO authorization, a habitat offsetting plan was developed and accepted. This plan was developed to re-establish and enhance the natural habitat not only for mussels but for all aquatic wildlife. This plan included the following:

- leaving the base layer of access pad rip rap embedded in the channel bottom;
- placing smaller, clean gravel over this layer to cover and fill the interstitial paces of the rip rap;
- Placing 20-30cm of courser material (larger gravel and cobbles) to increase the roughness of the spawning habitat
- scattering larger, clean, class 3+ material (boulders) across the footprint to create flow variability and promote egg settlement.

## Construction

The project was awarded for construction in July 2024. Construction began in August 2024, with traffic closures beginning in October 2024. The project is currently nearing completion of Stage 2, with the Stage 2 girders installed and Stage 2 concrete deck pours underway.

The project had two Sub-Completion dates, the first for the Substructure Modifications and Stage 1 by October 20, 2025, which was achieved. The second sub-completion date is for Stage 3 and the re-opening of the bridge to normal traffic by September 1, 2026. The tender has a Final Completion of November 20, 2026, which is anticipated to be met.

In general, there have only been minor complications during construction. At abutment SU1, field modifications to the concrete outline of the new footing were made to fit existing dimensions which did not match the as-built records. Additionally, one abutment caisson was not able to be installed in the design location as the drilling encountered subsurface obstacles (boulders) that they were not able to overcome. The design team was able to work with the Contractor to determine a revised caisson location with some modifications to the substructure concrete and reinforcement. Field changes to reinforcing dowels in the existing substructures were made in consultation with the Engineers based on field observations.