Graves Bridge High Load Damage Repair

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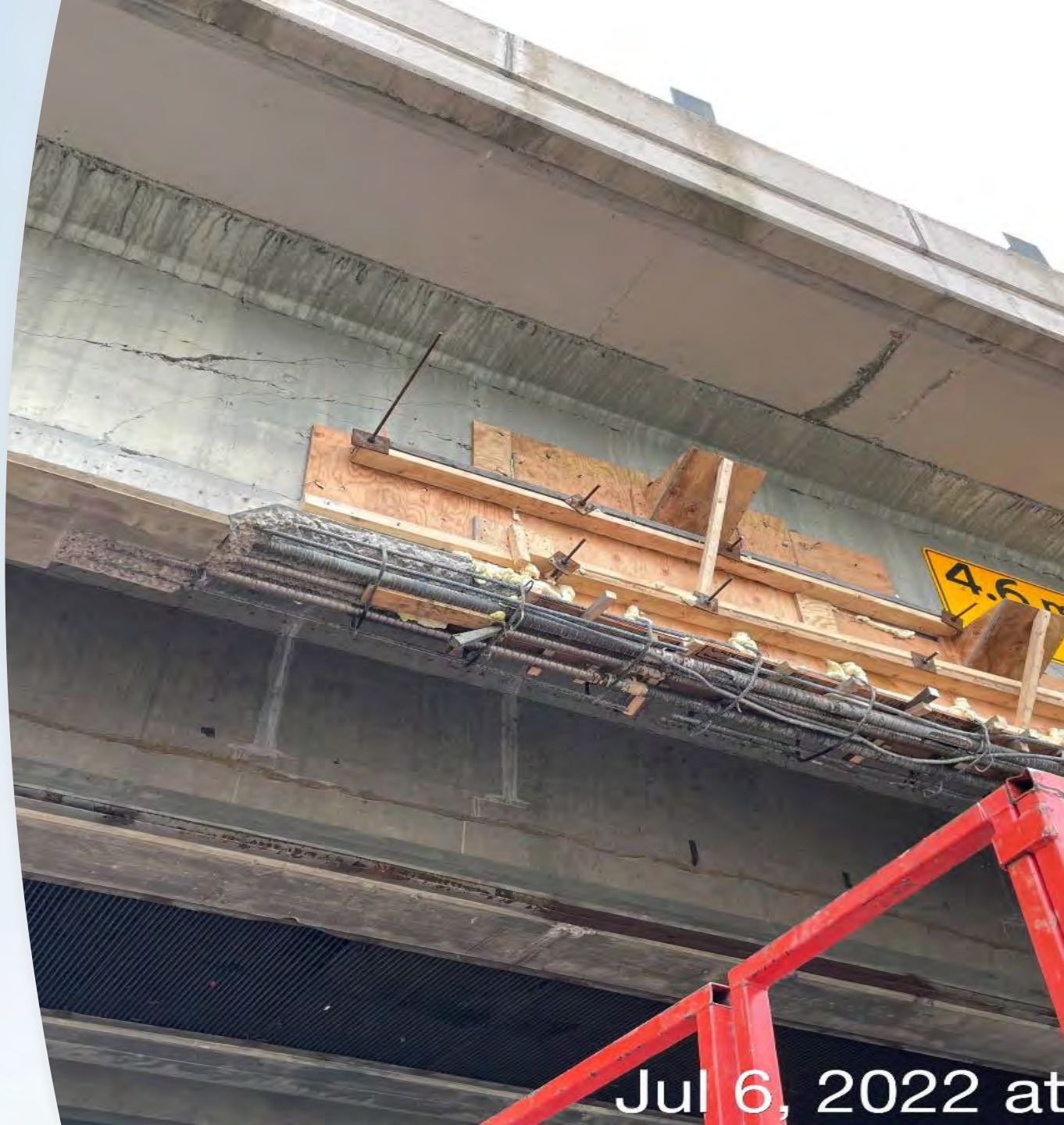
Agenda

- Project Schedule
- Bridge Introduction
- High Load Damage
- Challenging
- Assessment & Load Rating before Repair
- Repair Methodology
- Repair Staging
- Repair Design Details
- Traffic Accommodation
- Construction

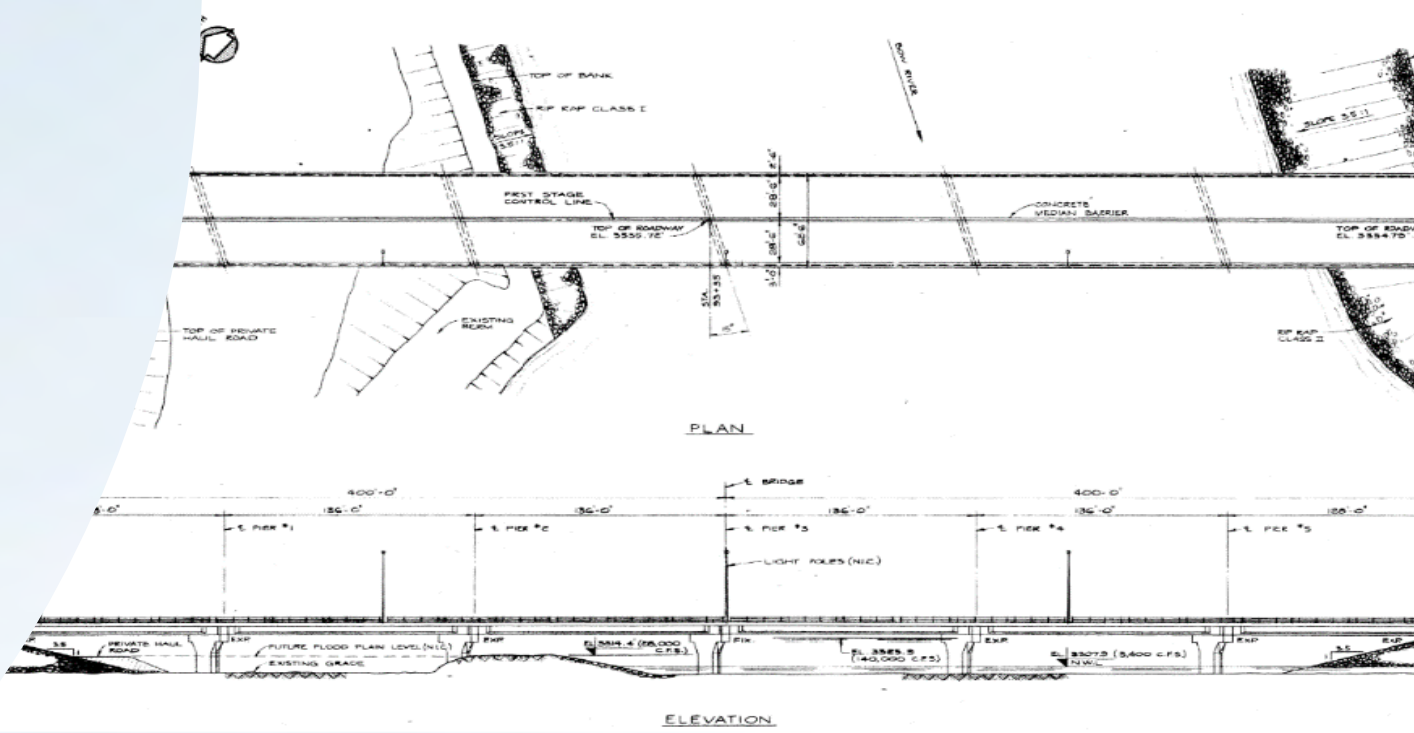


Project Schedule

- DAY 2 - SITE VISIT AND ASSESSMENT. CRACK MAPPING PREPARATION
- DAY 3 - KICK OFF MEETING WITH CITY. ASSESSMENT AND LOAD RATING COMMENCE
- DAY 16 - ASSESSMENT AND LOAD RATING COMPLETE. DRAFT MEMO SUBMITTED TO THE CITY FOR REVIEW
- DAY 18 - MEETING WITH CITY FOR DRAFT MEMO AND REPAIR METHODOLOGY
- DAY 20 - DETAILED REPAIR DESIGN COMMENCE
- DAY 50 - DETAILED REPAIR DESIGN COMPLETE AND DRAWING ISSUANCE FOR CITY REVIEW
- DAY 60 – ISSUANCE OF TENDER PACKAGE
- DAY 65 - PRECOSTRUCTION MEETING
- DAY 70 - CONSTRUCITON MOBILIZATION. CONSTRUCTION SUPERVISION COMMENCED
- DAY 120 – REPAIR CONSTRUCTION COMPLETE AND WAITING FOR ACCEPTANCE
- DAY 121 – CCC INSPECTION. REPAIR CONSTRUCTION COMPLETE

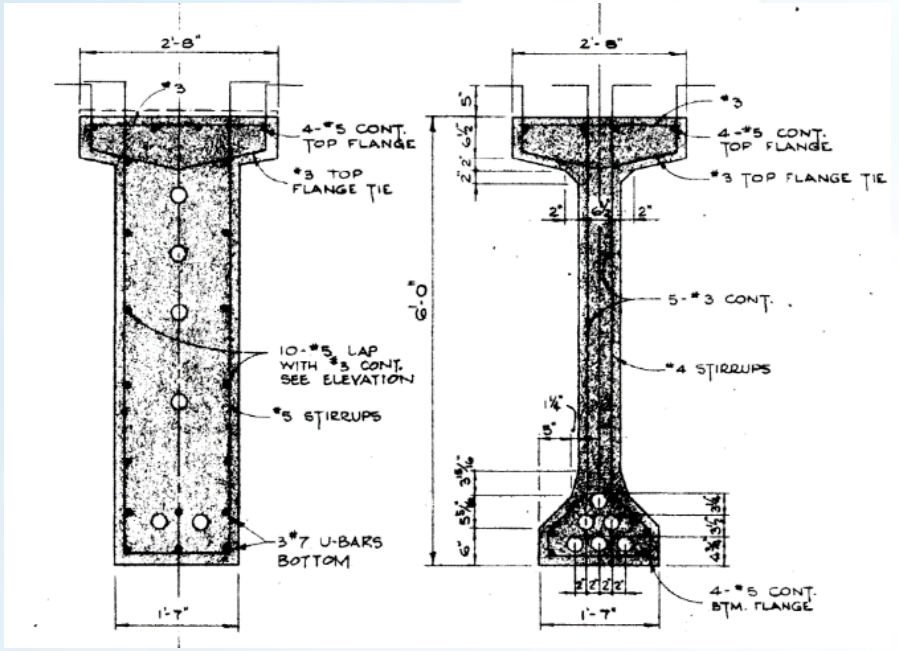
Bridge Introduction

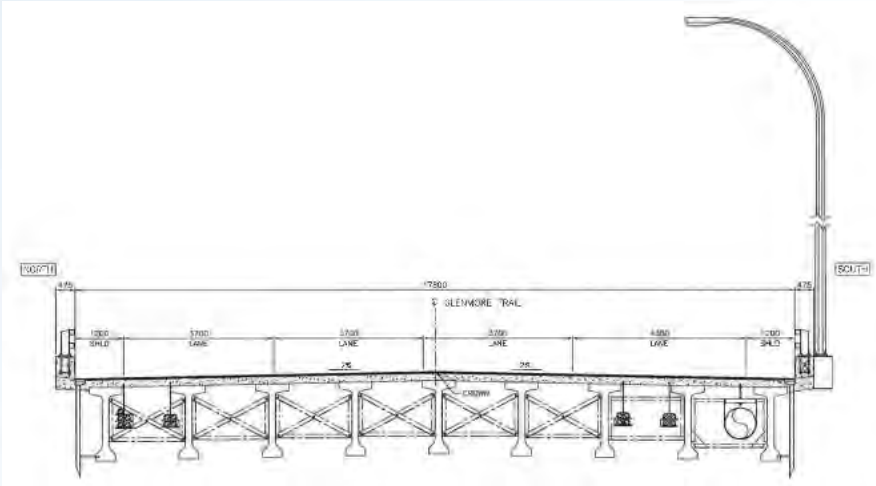
Graves Bridge is located at SE of Calgary, on Glenmore Trail, over Bow River and Heritage Drive SE



Bridge Introduction

- Originally constructed in 1970
- 6 spans 39 m – 4 x 41.5 m - 39 m
- Superstructure consists of 9 post-tensioned 1.83m deep Precast Concrete I Girder lines composite with 178 mm thick CIP deck, and 50 mm PMA wearing surface
- Simply support the self-weight and the deck load and continuous by the post-tensioned diaphragm at piers and the cast-in-place deck
- TL-5 Barrier Installed during Rehabilitation in 2009
- New PMA wearing surface was placed in during Rehabilitation in 2009
- Road Clearance Width: 17.8m
- Carries three 3.7m and one 4.3 traffic lanes on Glenmore Trail

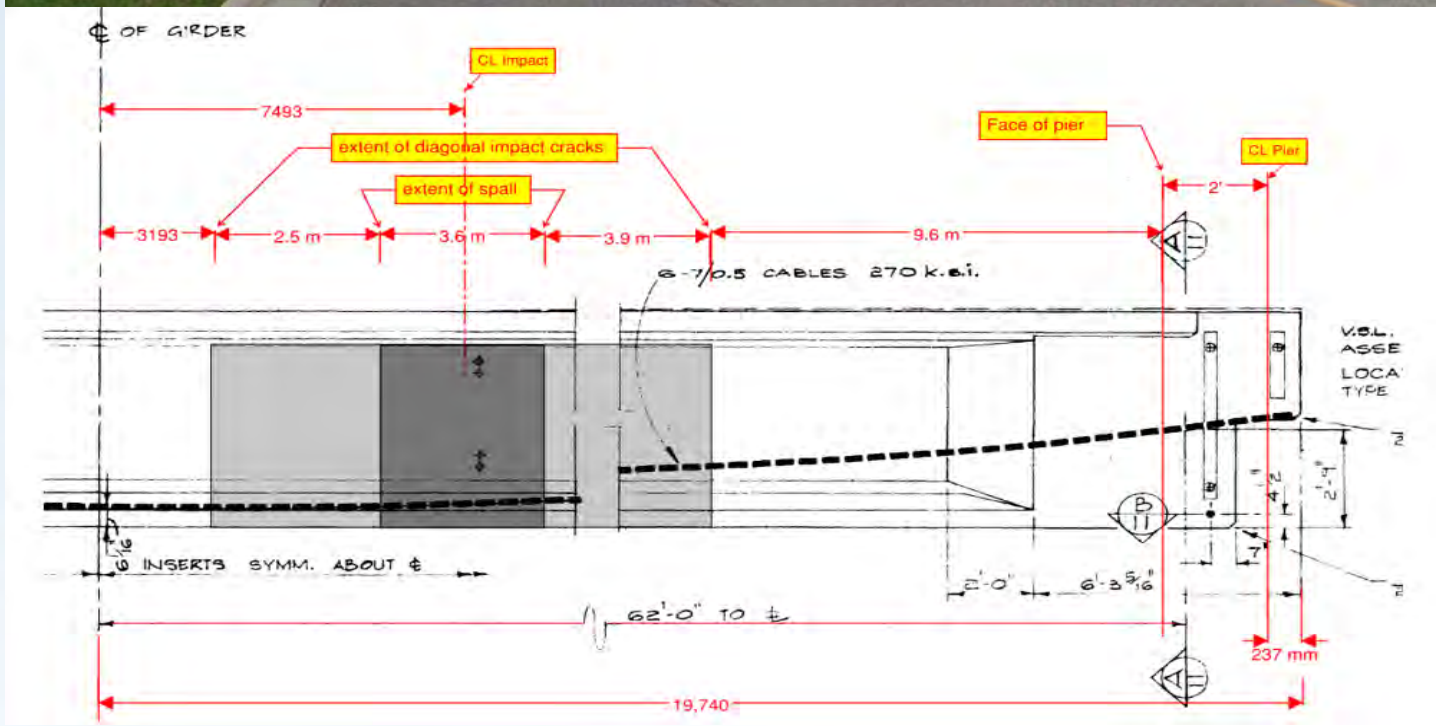




High Load Damage

High Load Damage

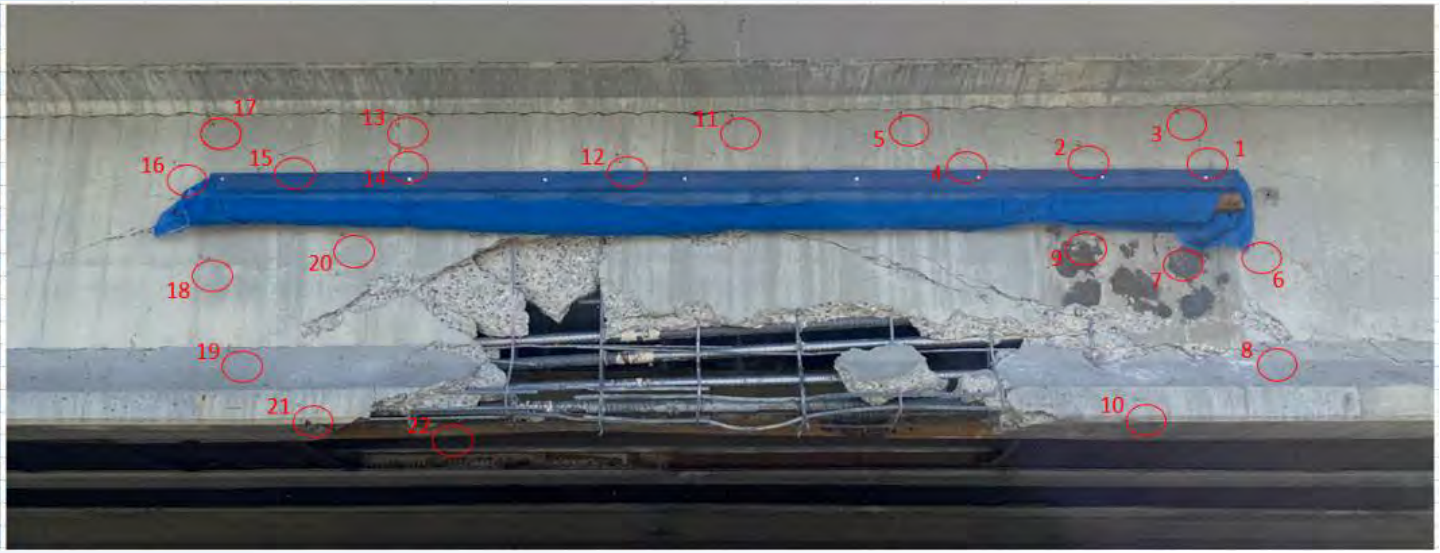
- **Date:** High load damage occurred in May 2022
- **Damage Location:** The south exterior girder of the first span was severely impacted by a dump truck at about 1/3 of the span length measured from the pier



High Load Damage

- **Damaged Condition**
  - Mass crash and breaking at bottom flange and lower portion of the girder's web
  - Extensive diagonal cracks at web
  - Long full depth crack between top flange and web
  - Part of post-tensioned tendons, stirrups, and reinforcing steels were exposed and debonded from concrete
  - Concrete spalls extend ±3.6 m while diagonal cracks extend about 10 m
  - Crack width ranges from 0.1mm up to 7 mm

No.	Width / Height (mm) 18-May-22	Description
1	0.75	Crack width
2	1.5	Crack width
3	3	Crack width
4	1	Crack width
5	5	Crack width
6	1.5	Crack width
7	0.8	Crack width
8	2	Crack width
9	5824	Vertical height from road
10	4960	Vertical height from road
11	7	Crack width
12	0.35	Crack width
13	5	Crack width
14	1.25	Crack width
15	2.5	Crack width
16	0.5	Crack width
17	3.5	Crack width
18	0.6	Crack width
19	2.5	Crack width
20	5749.5	Vertical height from road
21	4906	Vertical height from road
22	18	Duct to line on rebar



Challenging

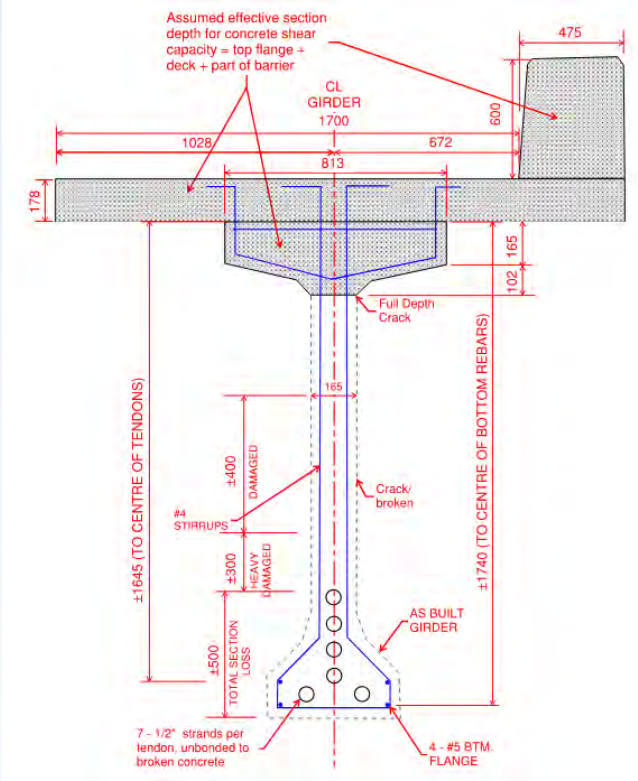
- **Schedule:**
  - The schedule was tight. The girder assessment, including load rating, repair methodology, and memo were completed within two weeks. The detailed design package was submitted within the next few weeks. The entire repair construction was completed within 4 months of the damage occurring.
- **Temporary Support:**
  - Temporary supports were not preferred because they would disrupt the traffic on Heritage Drive SE, especially during Stampede holidays.
- **Re-stressing:**
  - To prevent crack development in the girder bottom during service conditions, the damaged girder had to be re-stressed. However, re-stressing the existing tendons or adding new internal or external strands was impractical and even impossible for the damaged girder. Instead, preloading was considered.

Assessment & Load Rating

WSP bridge team in Calgary quickly reacted to the damage with prompt discussion with City representative and conducted a site visit followed by condition assessment and load rating to the damaged girder.

- Assumptions:

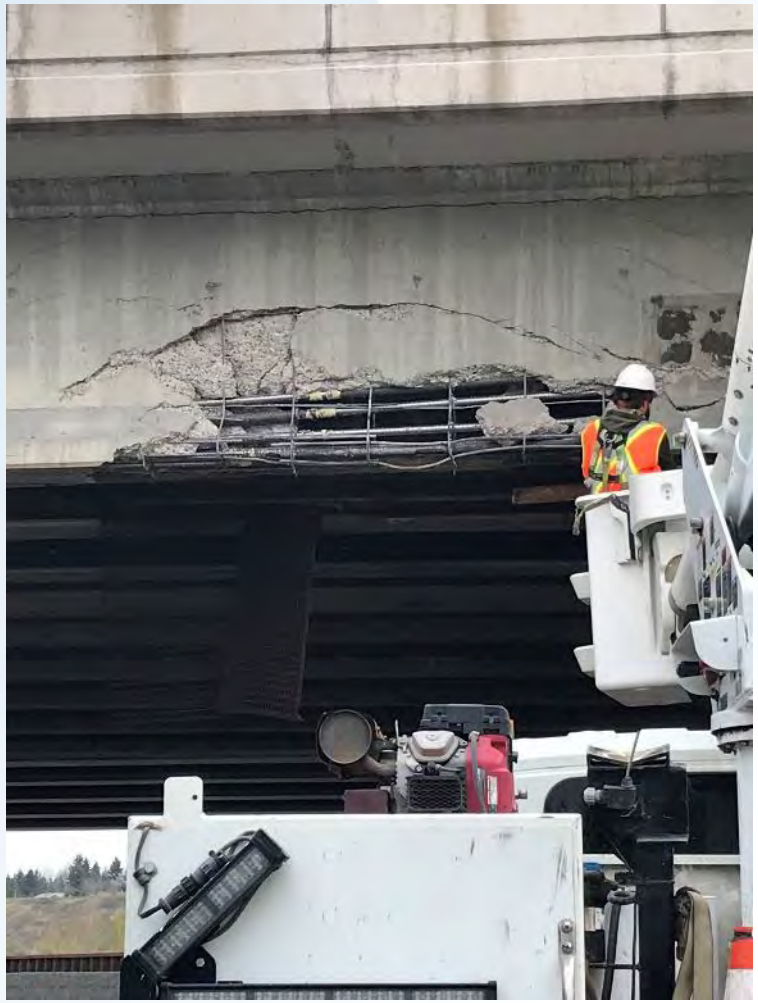
  - The live load analysis was based on a simplified method
  - Conservatively assumed the damaged girder still attracts the same loads as before
  - Conservatively assumed only the concrete of the deck, barrier, and the girder top flange are still in function.
  - Moment Evaluation: Assumed the concrete and major steels still comply with a strain and stress relationship to simplify the evaluation analysis and calculation.
  - Shear Evaluation: Include the deck, girder top flange, and a partial section of the TL-5 barrier for the shear resistance. Conservatively ignore the vertical component of the post-tensioned forces.



Section Considered for Load Raring Before Repair

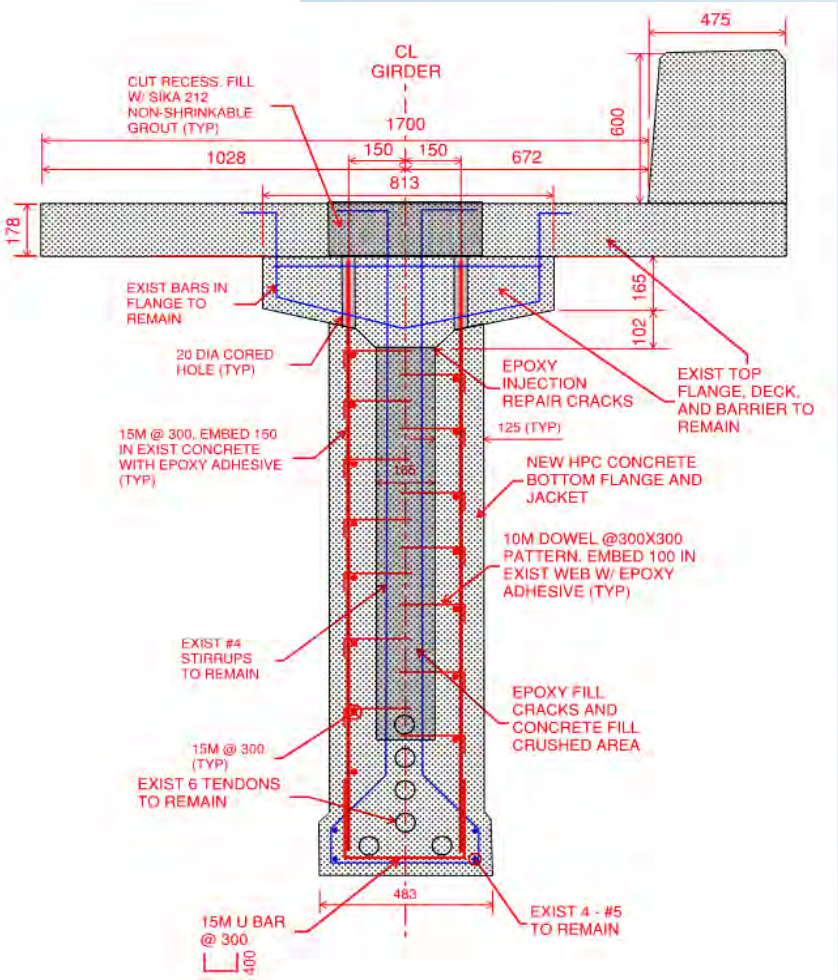
Assessment & Load Rating

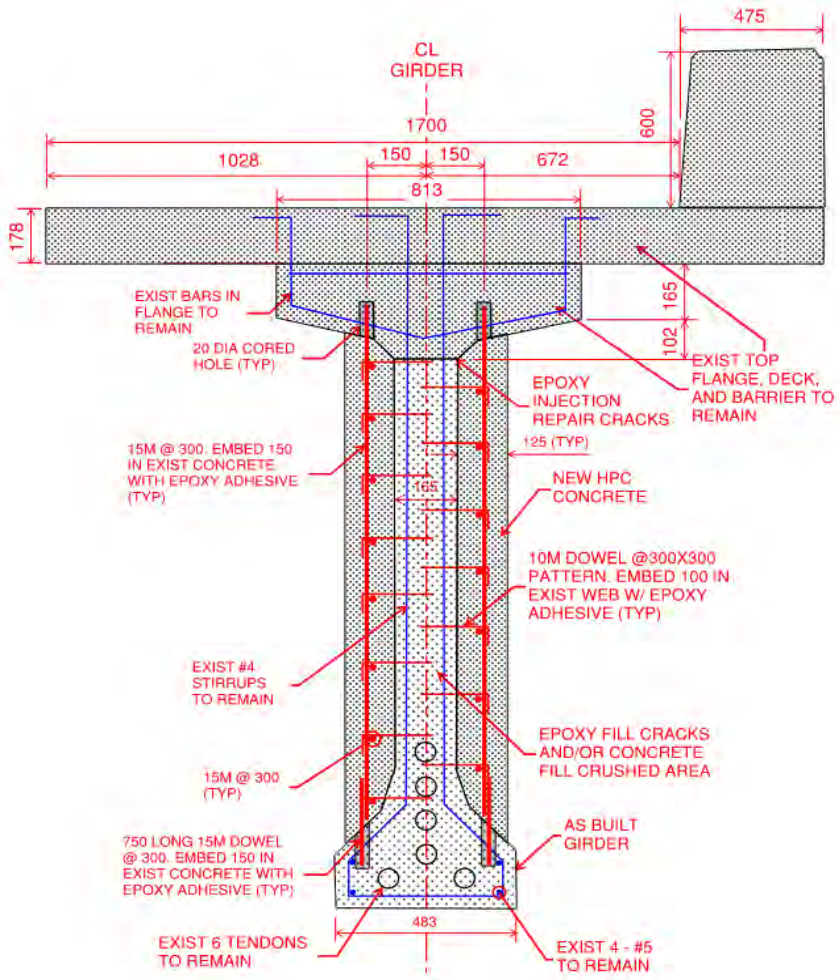
- **Results and Findings:**
  - The collision did not much affect the girder's flexural capacity. The damaged girder has sufficient capacity for the positive moment
  - There is no concern about the live load caused negative moment to the damaged girder, since it is counteracted by the positive moment of the dead loads.
  - The shear capacity of the damaged girder has been significantly reduced. The damaged girder itself has no sufficient shear capacity to carry either dead loads and/or live loads.
  - After including partial contributions to the shear resistance from the TL-5 barrier, it is prudently accepted that the composite section consisting of the deck, girder top flange, and the partial barrier still provides sufficient shear capacity to the dead loads.
  - In general, the damaged girder is still safe under the permanent loads, but not under traffic loads.



Repair Methodology

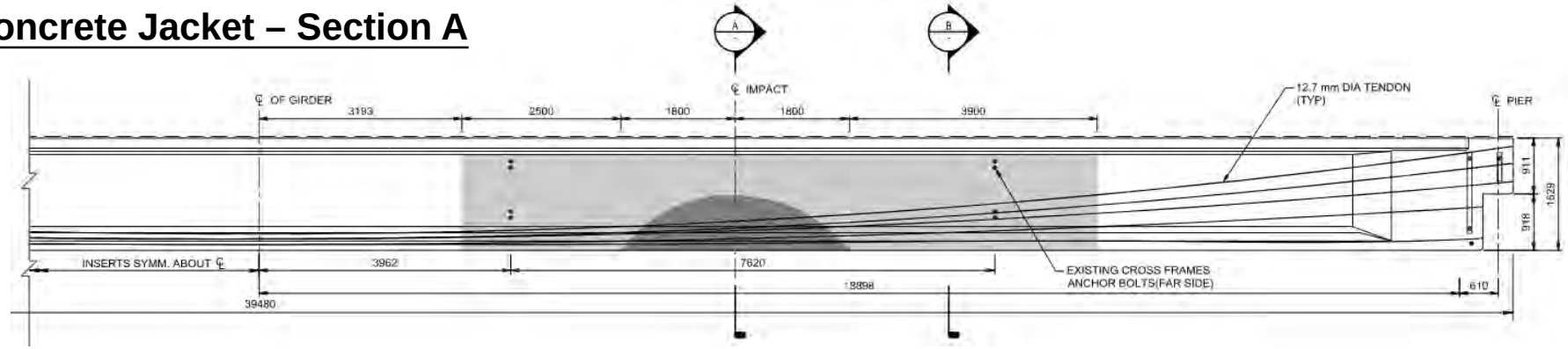
- **Concrete Jacket**

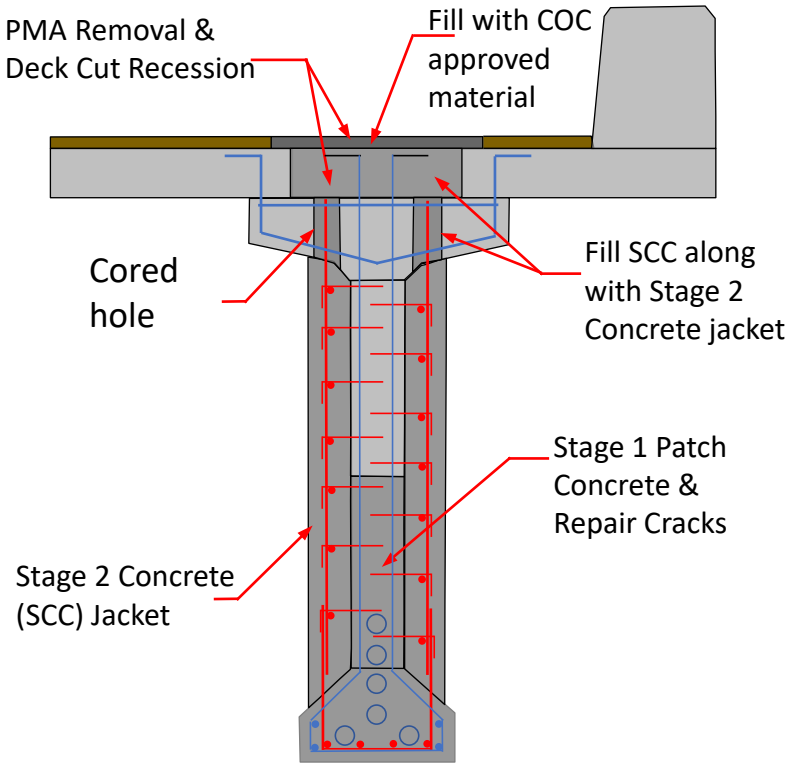




Repair Methodology

❑ Concrete Jacket – Section A

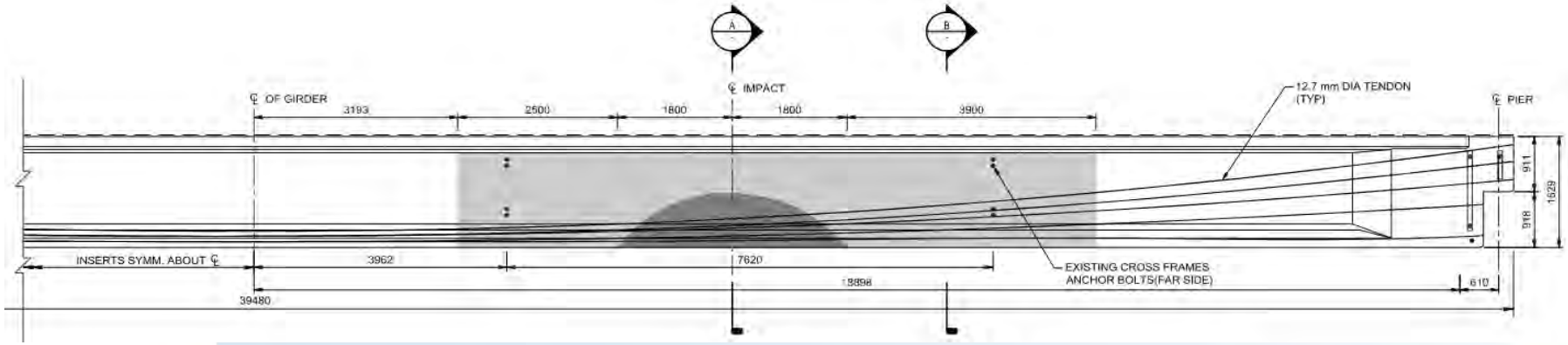


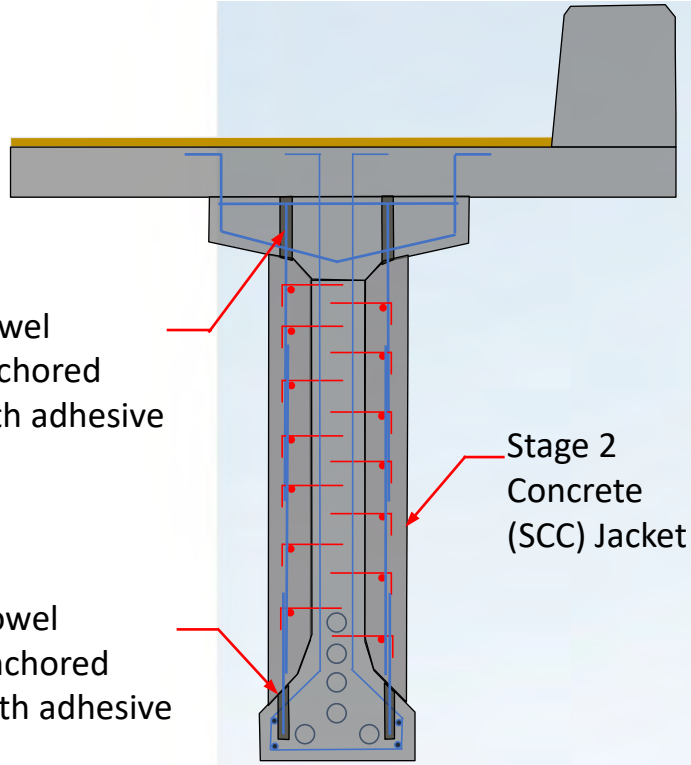


SECTION A

Repair Methodology

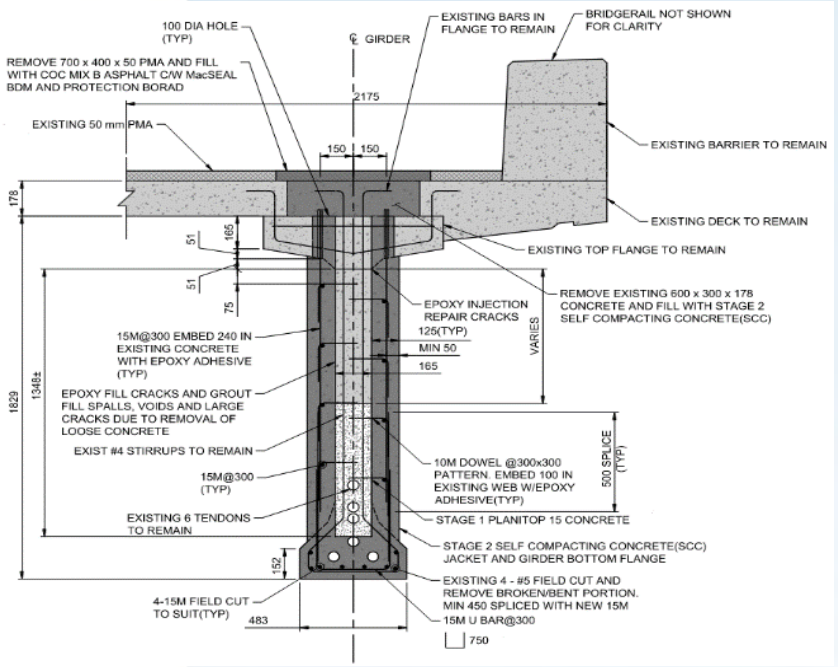
- **Concrete Jacket – Section B**

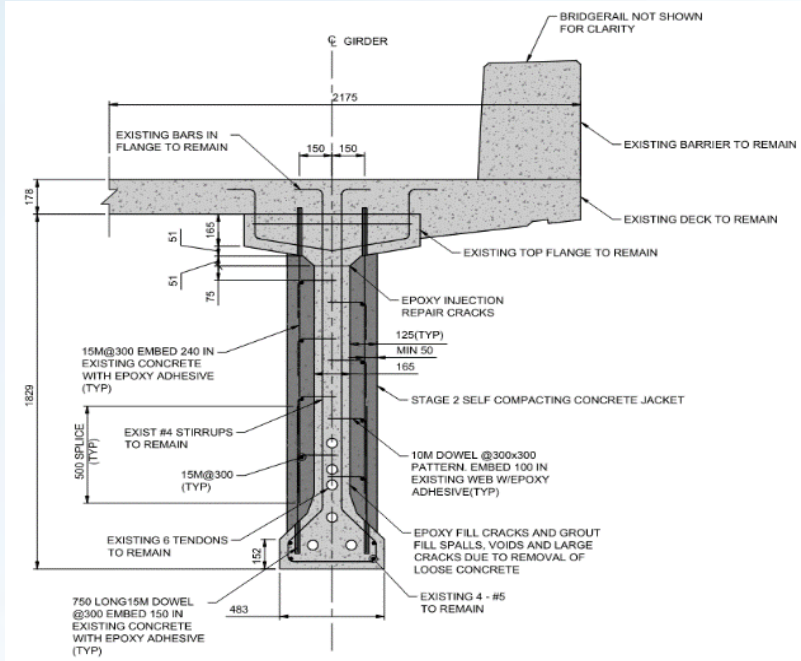




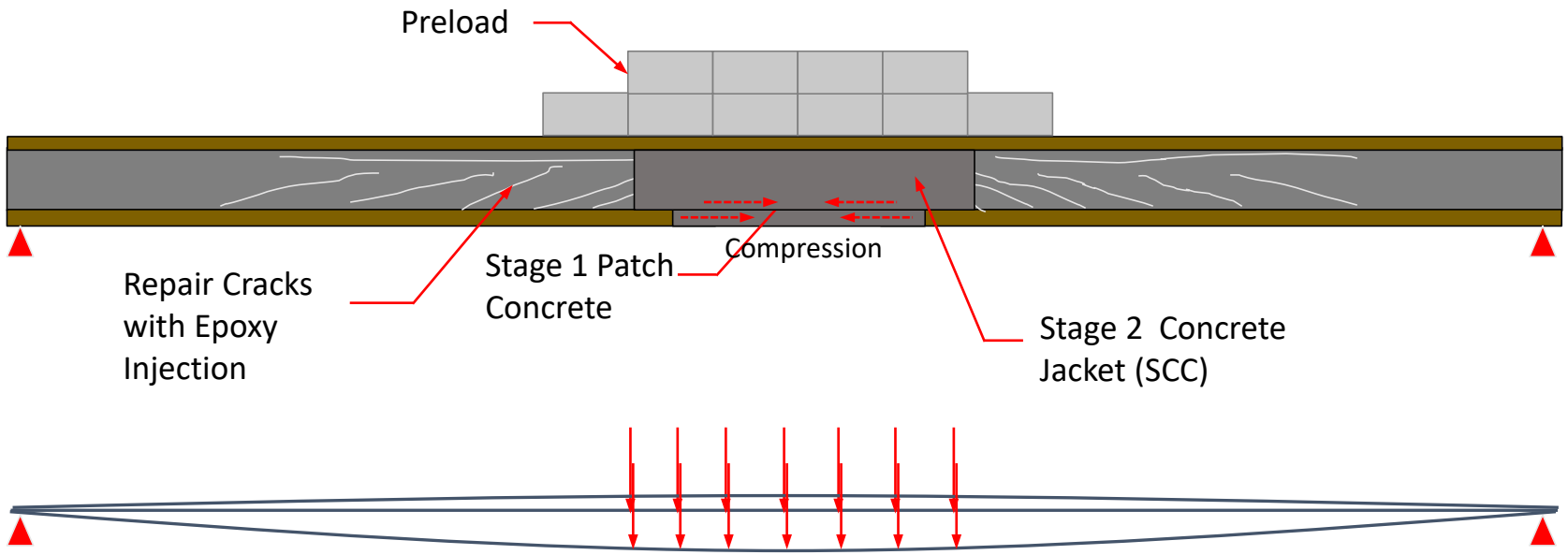
Design Details - Repair Staging

- REMOVE LOOSE CONCRETE FROM DAMAGED GIRDER.
- REPAIR ALL CRACKS GREATER THAN 0.2mm WITH FULL CRACK DEPTH EPOXY INJECTION
- GROUT FILL ALL DAMAGED PORTION AND CAST STAGE 1 CONCRETE AS SPECIFIED ON DESIGN DRAWING. CONTRACTOR SHALL FILED VERIFY THE EXTENT OF DAMAGES
- INSTALL ALL DESIGNED DOWELS AND REBARS AFTER FILLED GROUT AND STAGE 1 CONCRETE HAS BEEN CURED WITH FORMWORK LEFT IN PLACE FOR 72 HOURS AND THE POURED CONCRETE HAS ATTAINED 80% OF THE 28 DAYS STRENGTH
- APPLY PRELOAD TO SPECIFIED LOCATION
- CAST CONCRETE JACKET AND GIRDER BOTTOM FLANGE (STAGE 2) AS SPECIFIED ON DESIGN DRAWING
- REMOVE PRELOAD AFTER ALL CONCRETE HAS BEEN CURED WITH FORMWORK LEFT IN PLACE FOR 72 HOURS AND THE POURED CONCRETE HAS ATTAINED 80% OF THE 28 DAYS STRENGTH
- APPLY SEALERS ON REPAIRED SURFACES TO MATCH THE COLOR OF ADJACENT CONCRETE





Design Details – Preloading & Stressing

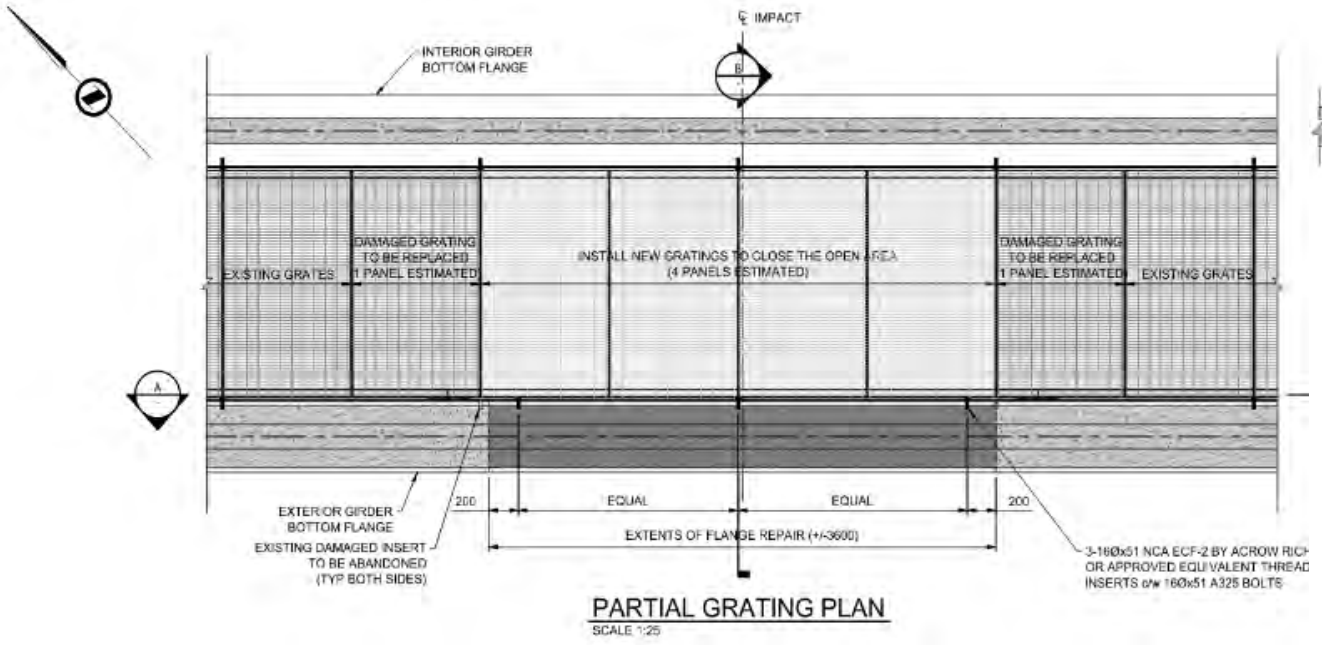


- PURPOSE: 1. COMPENSATE FOR DEAD LOAD LOSS IF SIGNIFICANT DEAD LOAD LOSS OCCURRED DUE TO DAMAGE. 2. PRE-STRESSING THE NEW CONCRETE AT GIRDER BOTTOM FLANGE
- FROM MECHANICAL POINT OF VIEW, PRELOADING IS REQUIRED
- ACCORDING TO AT'S CONCRETE BRIDGE ELEMENT REPAIR MANUAL, FOR CONCRETE BRIDGE ELEMENTS WITH MEDIUM TO SEVERE DAMAGE, THE DAMAGED GIRDER(S) SHALL BE PRELOADED TO OPEN UP THE CRACKS AND TO CREATE COMPRESSION IN REPLACEMENT CONCRETE AFTER UNLOADING
- THE PRELOADING SHALL BE UNIFORMLY DISTRIBUTED OVER THE CENTRE HALF OF THE GIRDER
- PRELOADING OPERATION SHALL BE FULLY MONITORED BY ENGINEER
- ADJUSTMENTS MAY BE MADE AS DEEMED NECESSARY
- THE PRELOAD MUST STAY IN PLACE UNTIL ALL THE CONCRETE PATCHING OR RECASTING, AND ANY CRACK INJECTION IS COMPLETED

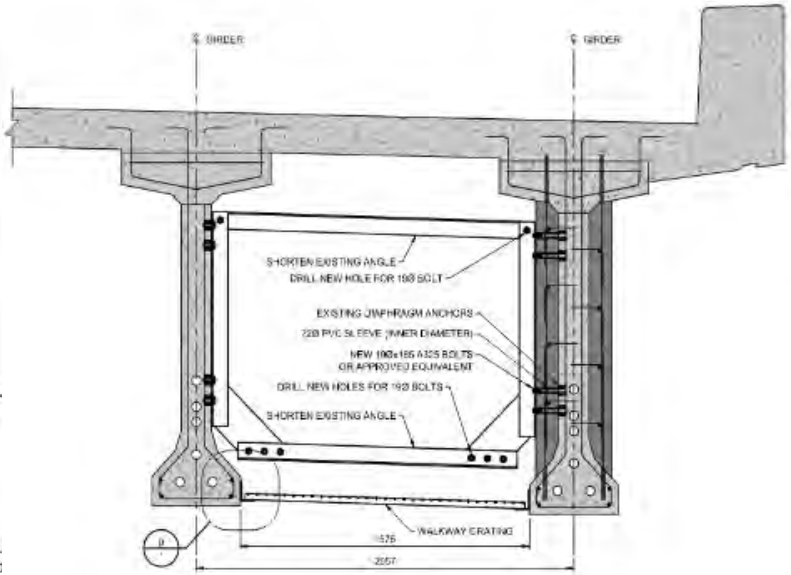
Design Details – Grating Replacement

Requirements and Method:

- Four damaged grating panels are to be replaced
- Due to the new concrete jacket on the web of the damaged girder, the existing frame angles can be salvaged, shortened, and re-installed in their original positions
- Existing anchor inserts are to be retained and used for new and longer anchor bolts
- Field-weld new support angle steel to existing steel frames. Tack-weld new grating to new support angle steel
- All new steel shall be galvanized



PARTIAL GRATING PLAN
SCALE 1:25



GIRDER SECTION

Traffic Accommodation

Following traffic accommodation measures were applied during the construction:

- Traffic Control on NE Glenore Trail
  - The outmost lane was closed
  - Maintain three traffic lanes
  - Temporary F-Shape Concrete Barriers were applied on the side lane

- Traffic Control on Heritage Drive
  - Maintain minimum one traffic lane Capacity for each direction
  - Temporary F-Shape Concrete Barrier, delineator, and safety cones were used

Construction – Stage 1: Crack Repair

❑ Crack Repair Material

Products and suppliers conform to AT's approved product list.

- Sikadur 52 Epoxy Resin for small cracks filling
- Sikadur 35 Hi-Mod LV Gravity-Flow Crack Filler for large cracks filling
- Sika AnchorFix 2020 was used at construction stage 1

❑ Crack Repair Procedure

- All cracks identified on the damaged girder and the all affected girders were filled
- All cracks were sealed after installing the injection ports

Construction - Stage 1: Patching

Based on the repair design requirement, 2-stage repair construction were conducted.

- All loose concrete has been removed
- All cracks were filled with epoxy injection prior to the patching
- Formwork placed prior to patch application

Formwork for Patch at Stage 1

Formwork for Patch at Stage 1

- PlainTop 23 patch material was placed and cured for 7 days prior to preloading
- PlainTop 15 patch material was placed and cured for 7 days prior to preloading

Construction - Stage 2: Preloading

❑ Preloading Concrete Block

- Lafarge 1.8 tons Concrete Block
  - 1520mm Length
  - 760mm Height
  - 760mm Depth
  - 1860kg (4100lbs) Mass
- Concrete Bocks were placed centered damage girder and adjacent to the bridge barrier

❑ Reloading Deflection Survey

- The entire preloading process was thoroughly monitored and surveyed
- GeoVerra conducted the deflection survey during the preloading procedure
- The design expected 15mm deflection at the centre of the damaged area was achieved when 30 Lafarge concrete block were placed

Construction - Stage 2: Concrete Jacket

❑ Deck Recession Cut

- REMOVE EXISTING PMA WITH THE AREA OF 700 mm x 400 mm at 4 LOCATIONS
- CUT EXISTING DECK WITH AREA OF 600 mm x 300 mm at 4 LOCATIONS
- CHIP THROUGH THE GIRDER WITH 100 DIA HOLE

Reinforcing Steels/dowels for Concrete Jacket

Deck Recession Cut for Pouring Concrete

❑ Reinforcement/Dowel Installation

- Vertical dowels were installed from top of flange
- Reinforcing steels spliced with dowels with sufficient overlap length
- Horizontal dowels for web were installed with Hilti adhesive

Construction - Stage 2: Concrete Jacket

❑ CONCRETE JACKET PLACEMENT

- POUR STAGE 2 SCC CONCRETE THROUGH THE DECK CUT RECESSIONS
- CONCRETE WAS POURED FLUSH WITH EXISTING CONCRETE DECK
- HAND VIBRATION TOOL WAS USED

Pouring SCC Concrete Jacket

Formwork and Reinforcement for New Jacket

❑ CONCRETE JACKET CURING

- THE CONCRETE JACKET WAS CURED FOR MORE THAN 14 DAYS PRIOR TO THE FORMWORK REMOVAL
- THE CONCRETE STRENGTH REACHED 80% OF THE 28 DAY DESGN STRENGTH

Construction - Stage 2: Deck Recession Repair

DECK RECESSION CUT FOR GIRDER JACKET WERE FILLED THEREAFTER

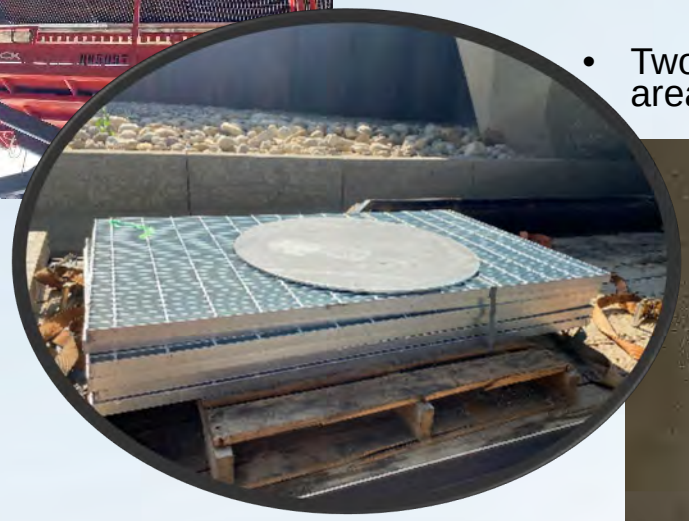
- SAWCUT 5 mm x 8 mm AROUND THE PERIMETER OF NEW CONCRETE
- APPLY SIKADUR 55 INTO THE SAWCUT AREA
- LIGHTLY BRUSH BLASTED THE AREA PRIOR TO APPLY WATERPROOFING MEMBRANE
- APPLY 5 mm THICK LAYER OF MacSEAL BDM ROUND THE REMOVED PMA AREA

MacSeal BDM Application

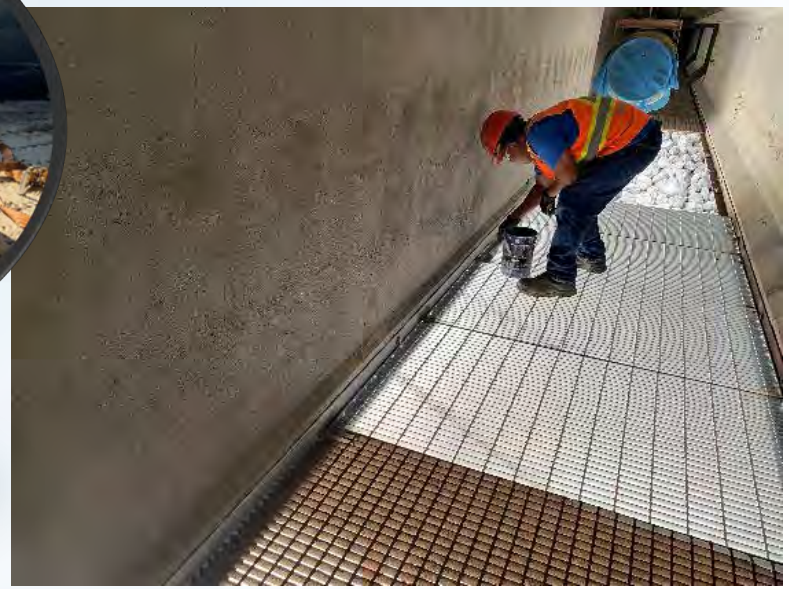
Cut Recession filled with COC Mix-B Asphalt

- PLACE A 3.2 mm THICK PROTECTION BOARD OVER THE AREA
- APPLY TACK COAT ABOVE THE PROTECTION BOARD
- PLACE COC MIX-B ASPHALT AND COMPACT WITH SMALL PLATE TAMPER
- SAWCUT 10 mm x 10 mm AROUND THE PERIMETER EDGE OF THE ASPHALT PATCH
- APPLY MacSEAL BDM AROUND THE PATCH

Construction - Grating Replacement



- Remove damaged existing grating (4 pieces) and corresponding frames and bolts
- New grating fabrication and hot-dip galvanized (4 pieces)
- Install new galvanized grating and relevant frames
- Two coats of zinc rich paint to the field welding areas



Zinc Rich Paint Field Welding Area

- Relevant Other Work: Weld the galvanized cap to existing water main

Construction – Sealer Application

Sealer application and site restoration are the final steps of the repair construction.

- Pressure wash the surface prior to the sealer application
- Apply Type 3 pigmented (Color: Banff Beige) sealer to the exterior surface of the damaged girder
- Apply Type 1c sealer to the repaired area on the inside surface of the damaged girder

Type 1c Sealer Application

Type 3 Pigmented Sealer Application

Material:

Products and suppliers conform to AT's approved product list.

- Type 3 Pigmented Sealer - Sikagard A50 Lo-VOC (Color: Banff Beige)
- Type 1c Penetrating Sealer – DRE Dry-Trete 1000L

Questions Welcome

Repaired girder with Pigmented Sealer Application

wsp.com