GFRP concrete reinforcement type

Applications in Bridge Decks

Learning Objectives

- Demonstrate GFRP performance and use in hundreds of real life bridge projects
- Understanding how GFRP removes corrosion from the equation – Life Cycle Costing
- Seeing exponential growth as various design codes, specifications and corrosion policies evolve
- Understanding how applications expand as engineers utilize its performance and Codes

FIBEROX

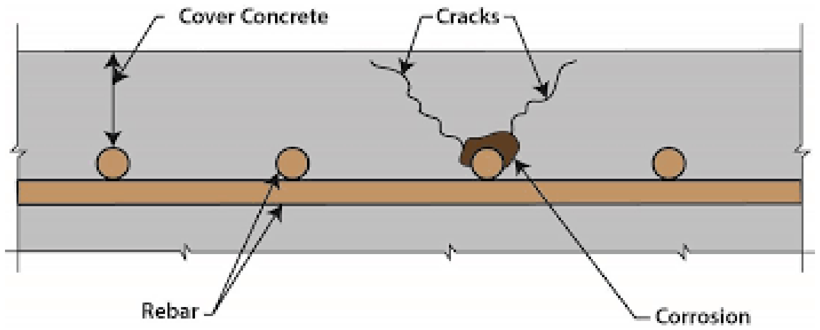
Presentation Outline

- Why GFRP composite reinforcing
- Design codes and certifications
- GFRP overview
- Life Cycle Costing/Carbon footprint
- TL-5 barrier crash test
- Examples of cast in place bridges
- Rehabilitation
- Examples of precast bridges
- Conclusion

Why GFRP Composite Reinforcement

As engineers strive to deliver owners with more sustainable, safe and durable concrete structures, glass fiber reinforced polymer (GFRP) reinforcing is being used in innovative ways in a large range and scope of bridge decks and other structural components.

As opposed to more concrete cover, inhibitors or other corrosion protection measures, take care of the root problem in utilizing high performance, non-corrosive V-ROD GFRP!



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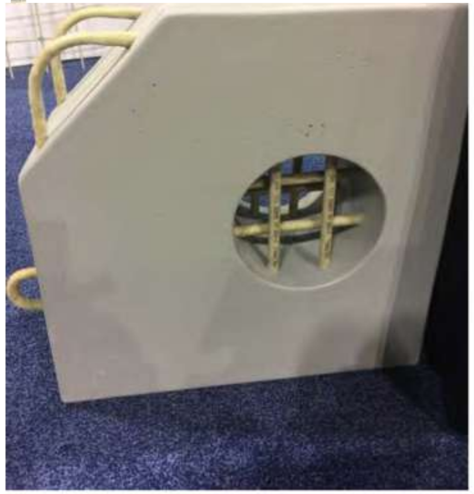
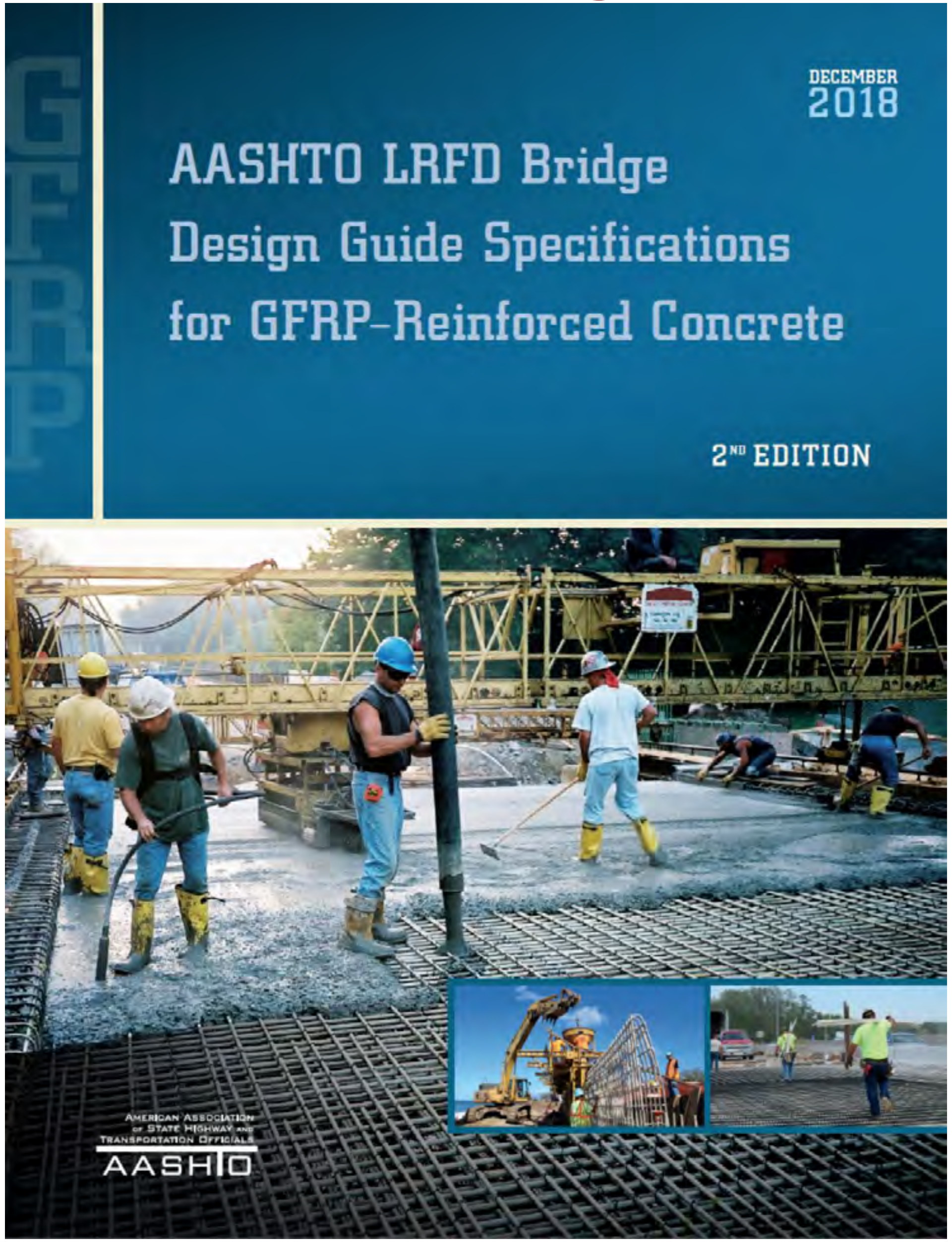
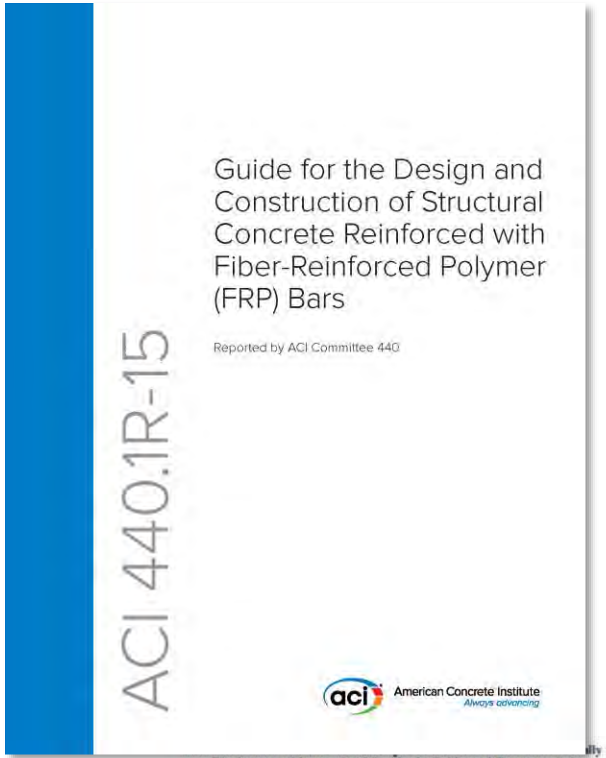
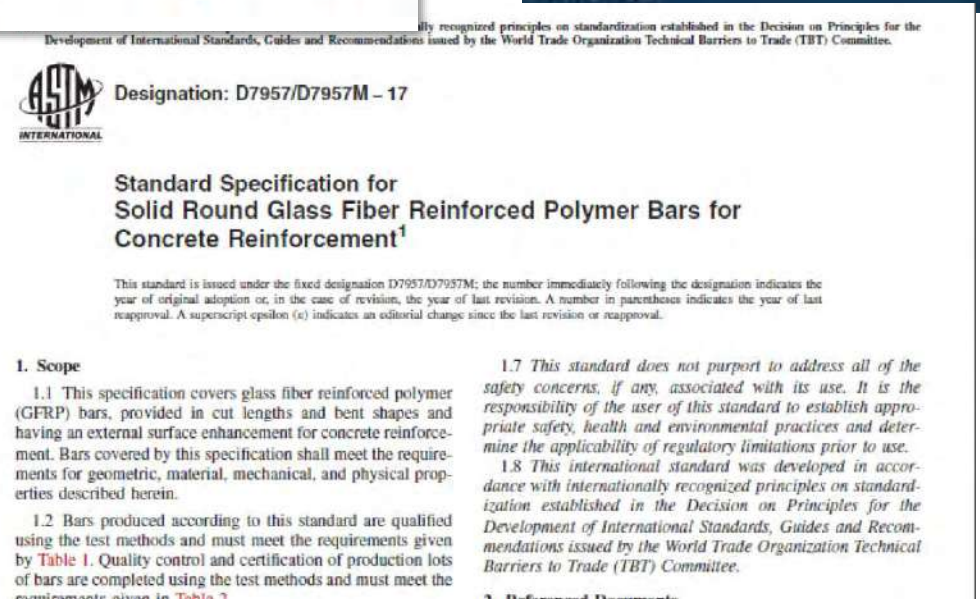


FIBEROX

Design Codes & Certifications - USA







...lly recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

ASTM INTERNATIONAL

Designation: D7957/D7957M – 17

Standard Specification for Solid Round Glass Fiber Reinforced Polymer Bars for Concrete Reinforcement[1]

This standard is issued under the fixed designation D7957/D7957M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers glass fiber reinforced polymer (GFRP) bars, provided in cut lengths and bent shapes and having an external surface enhancement for concrete reinforcement. Bars covered by this specification shall meet the requirements for geometric, material, mechanical, and physical properties described herein.

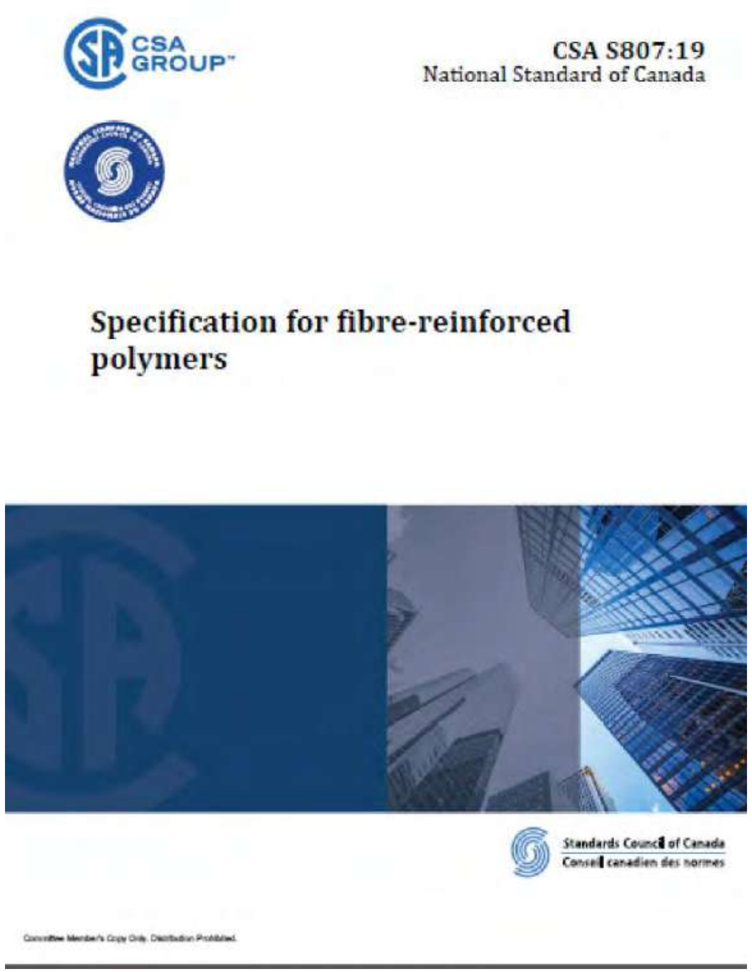
1.2 Bars produced according to this standard are qualified using the test methods and must meet the requirements given by Table 1. Quality control and certification of production lots of bars are completed using the test methods and must meet the requirements given in Table 2.

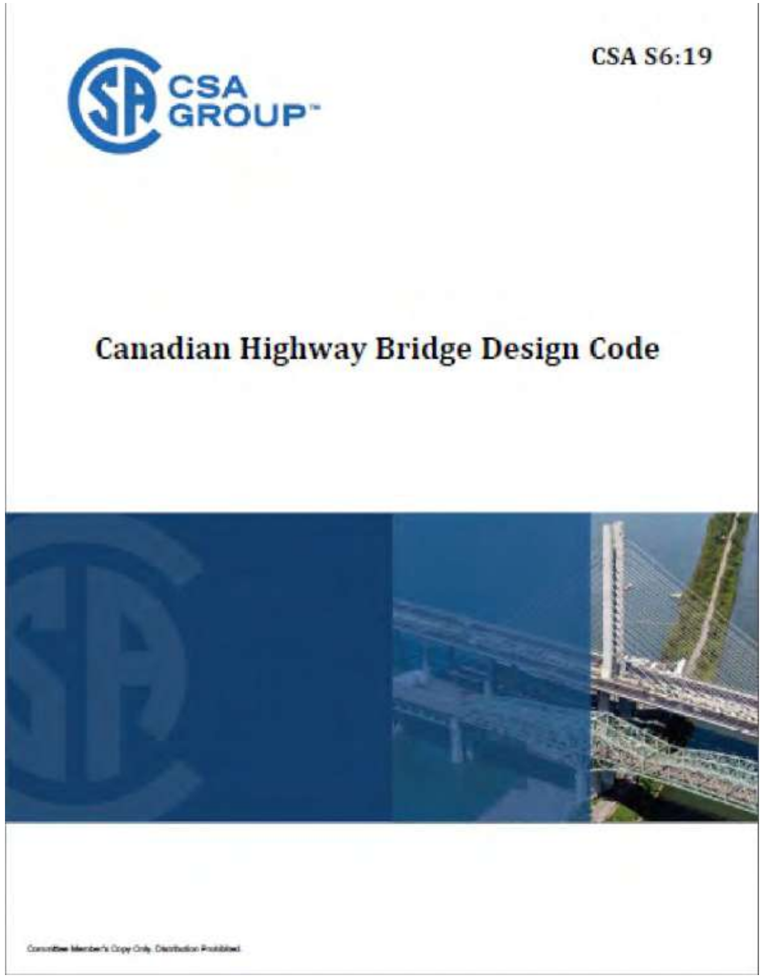
1.7 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health and environmental practices and determine the applicability of regulatory limitations prior to use.

1.8 This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

Design Codes & Certifications - Canada





Overview of FRP Composite Reinforcement

With GFRP reinforcing used in hundreds of successful infrastructure projects to date, projects are becoming larger and more complex. Applications include new or rehab bridge construction of decks/barriers/approach slabs, sidewalks as well as precast bridge decks, box girders, RSS walls and curbs. Other applications include transit (LRT/BRT's), WTP's, parking garages, hydro/substations, airports, marine structures, mining, MRI's, tunneling etc

- superior tensile properties
- built-in corrosion resistance (non-corrosive)
- impervious to salt ions, chlorides and chemicals
- electrically/magnetically neutral (non-conductive)
- thermal benefits
- one-quarter the weight of steel
- FRP bridge/building codes and design manuals including ACI 440.1R and AASHTO LRFD in USA
- complies with ASTM D7957-17 Specification
- can be easily cut ie tunneling soft-eyes

As opposed to traditional design methods and materials, FRP's are 30% less cost than other alternatives as Life Cycle Costing evaluates the **total costs of ownership**.

FIBEROX

Life Cycle Costing/LCA

Thomas Cadenazzi,[1] Giovanni Dotelli,[2] Marco Rossini,[3] Steven Nolan,[4]
and Antonio Nanni[3]

Life-Cycle Cost and Life-Cycle Assessment Analysis at the Design Stage of a Fiber-Reinforced Polymer-Reinforced Concrete Bridge in Florida

Reference

T. Cadenazzi, G. Dotelli, M. Rossini, S. Nolan, and A. Nanni, "Life-Cycle Cost and Life-Cycle Assessment Analysis at the Design Stage of a Fiber-Reinforced Polymer-Reinforced Concrete Bridge in Florida," *Advances in Civil Engineering Materials* 8, no. 2 (2019): 128–151. https://doi.org/10.1520/ACEM20180113

ABSTRACT

To support and promote the deployment of innovative technologies in infrastructure, it is fundamental to quantify their implications in terms of both economic and environmental impacts. Glass Fiber-Reinforced Polymer (GFRP) bars and Carbon Fiber-Reinforced Polymer (CFRP) strands are validated corrosion-resistant solutions for Reinforced Concrete (RC) and Prestressed Concrete

Comparing conventional and innovative bridge deck options: A life cycle engineering and costing approach

K.J. Kostuk
Industrial Engineer, Federated Co-operatives Limited, Saskatoon, Saskatchewan, Canada

G.A. Sparks
Professor, University of Saskatchewan, Saskatoon, Saskatchewan, Canada

P.N. Christensen
Professional Affiliate, University of Saskatchewan, Saskatoon, Saskatchewan, Canada

G. Tadros
President, SPECO Engineering, Calgary, Alberta, Canadaa

ABSTRACT: Engineering design is a complex process facilitated by experience and past practice. Design methods, concrete and surface options, reinforcement materials, and geometry, combine to permit hundreds – if not thousands – of possible bridge deck alternatives. Given such a staggering list of possible options, a traditional, stepwise, deterministic life cycle costing (LCC) approach inevitably bogs down in its search for optimality. Moreover, the results reached fail to inform decision-makers of the risks surrounding each deck alternative and may, therefore, limit confidence in any recommendations emerging through the LCC analysis. The authors of this paper, propose an iterative life cycle engineering and costing (LCE&C) approach to gradually hone a list of potential deck design alternatives. Embracing uncertainty in an explicit way, the results derived and reported herein provide decision-makers with comparable, stochastic life cycle cost estimates.

FIBEROX

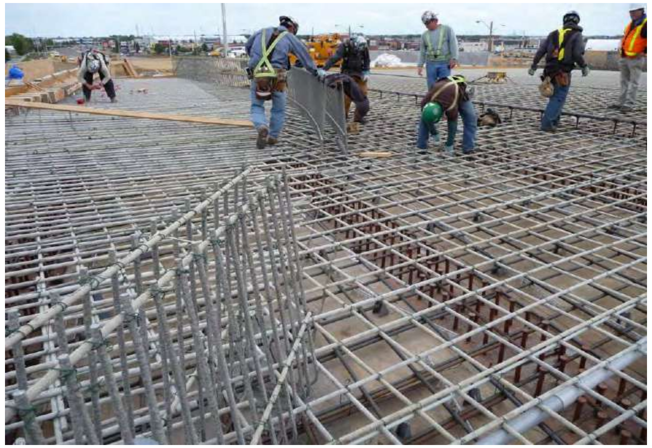
Crash test of TL-5 Barriers by VRod

Crash Test at Texas TTI with 60Gpa headed bar now approved for TL-5 barriers

FIBEROX

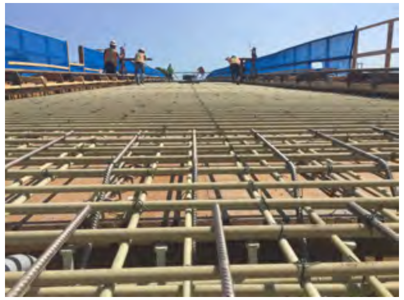
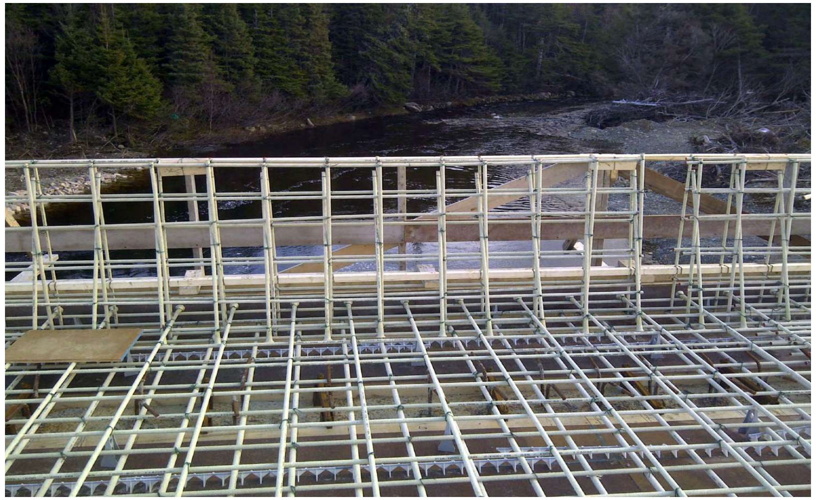
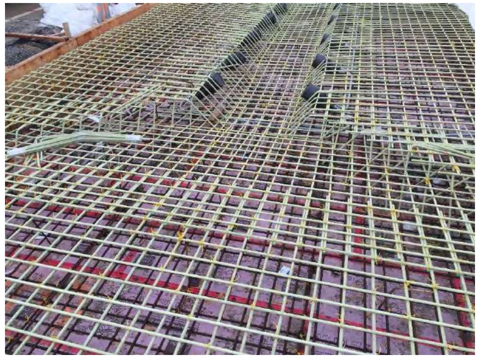
FIBEROX

Project examples of Cast in place bridge decks








Wotten Bridge 2001 – QC

MTQ - Hwy 410 overpass in Sherbrooke, QC

MTQ - Hwy 410 overpass in Sherbrooke, QC

FIBEROX

Cookshire Bridge 2003 – Cookshire, QC

Val Alain Bridge 2004 – Hwy 20E, QC

FIBEROX

Bridgeport Bridge deck replacement Region of Waterloo, ON

Dorchester Bridge, Kitchener, ON

FIBEROX

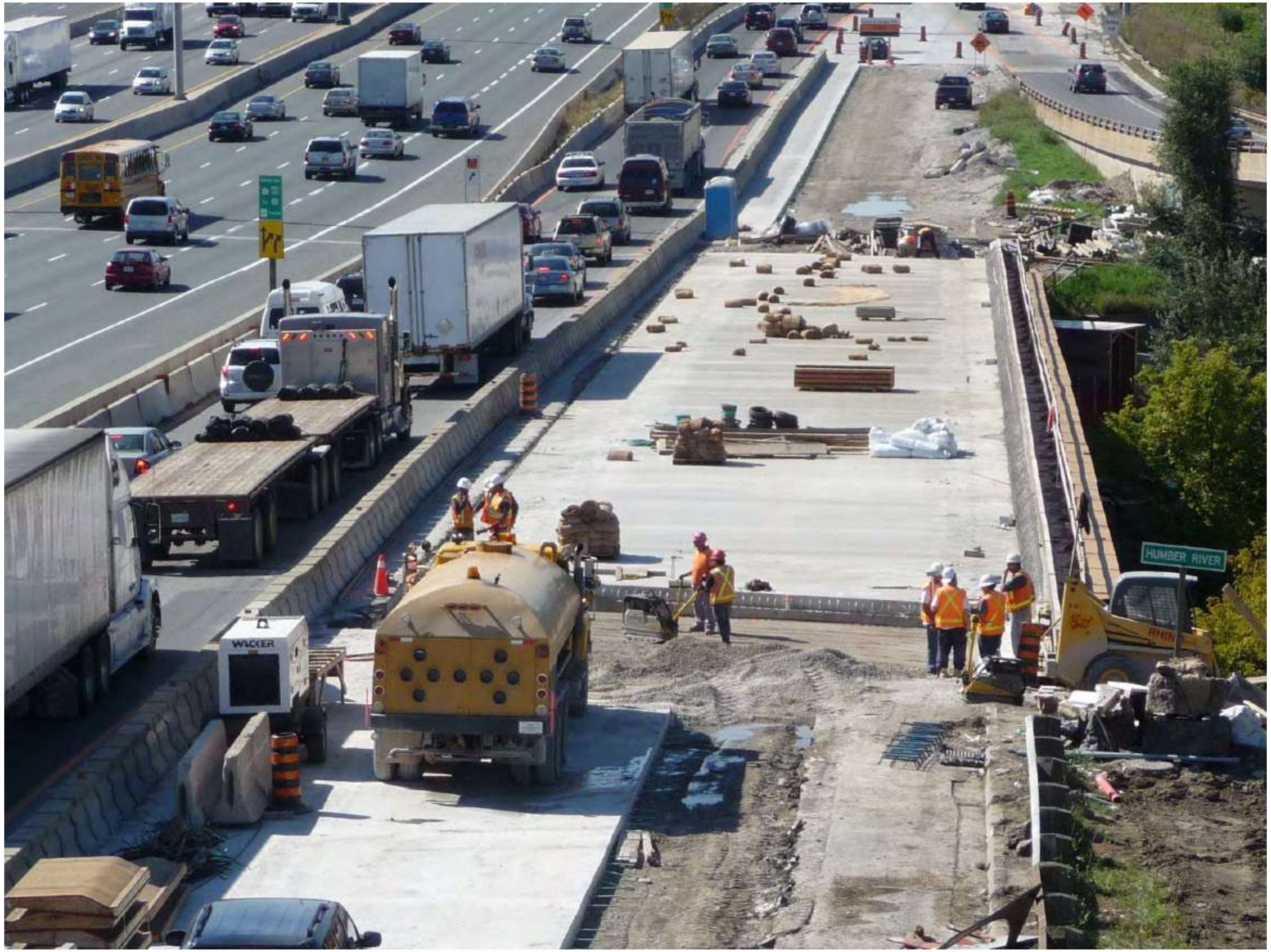
Skagit River Bridge – BC MOT

FIBEROX

MTO 2009-2020 (Hwy 401 in Toronto) multiple cast in place deck structures

FIBEROX

MTO 2009-2020 (Hwy 401/Islington Ave completed deck



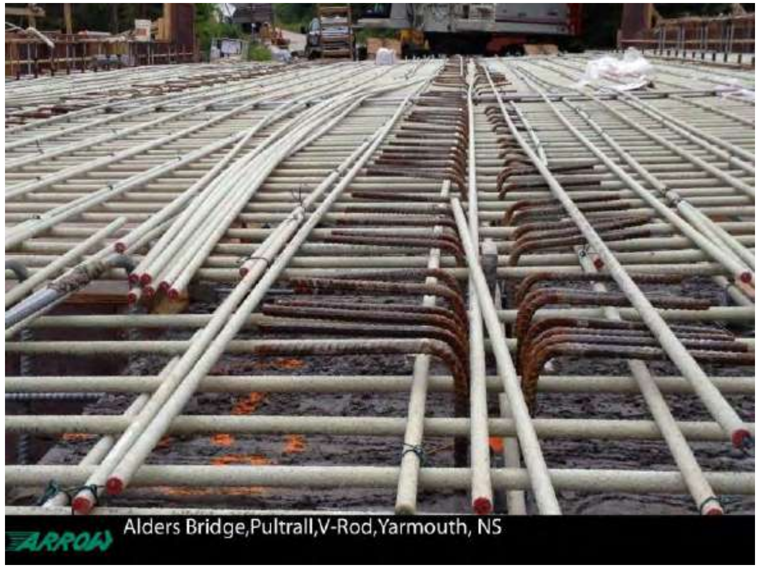
Rattle Brook Bridge - N’fld DOT - 2011

Rattle Brook Bridge N'fld - 2011

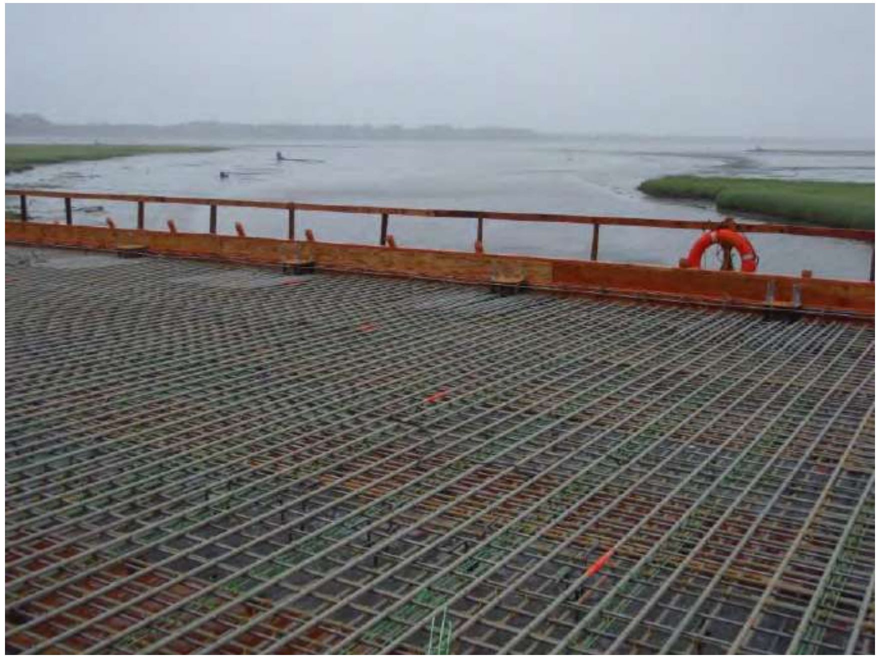
Montague Bridge, PEI, 2006

Victoria Bridge, PEI, 2009

Alders Bridge, NS, 2015



Millport Slough, Oregon

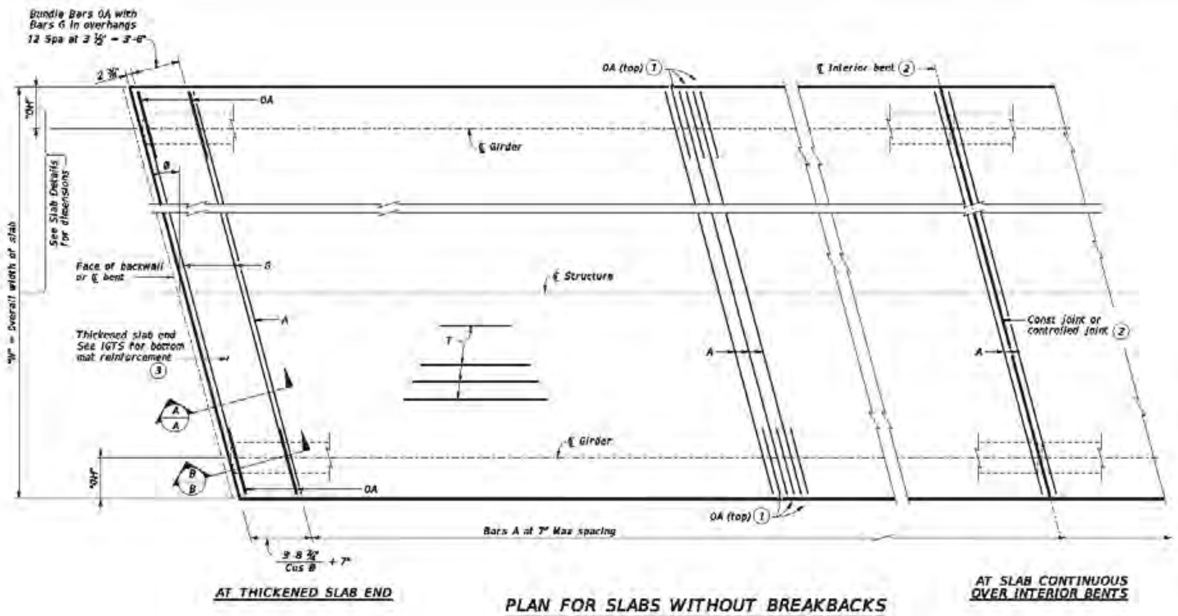


FIBEROX

Morristown Bridge, Vermont

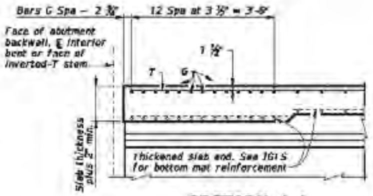
FIBEROX

Baudette Bridge, MNDOT



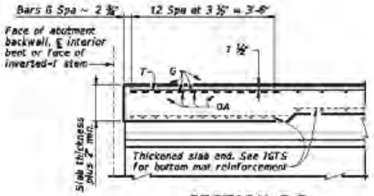
PLAN FOR SLABS WITHOUT BREAKBACKS

Showing top mat reinforcement only.



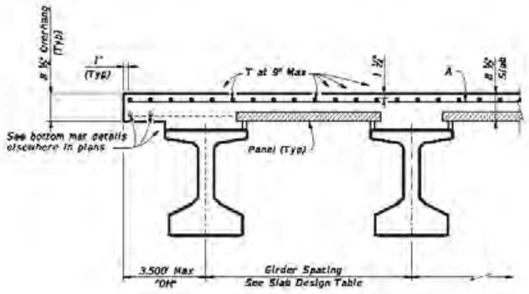
SECTION A-A

Showing Thickened Slab End with PCP Option 1. Option 2 similar.

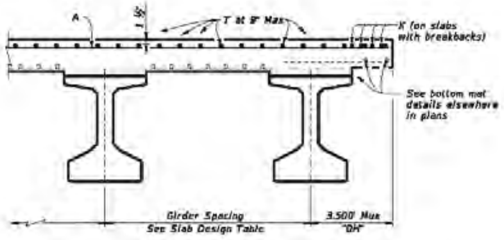


SECTION B-B

Showing Thickened Slab End with PCP Option 1. Option 2 similar.



PARTIAL TYPICAL TRANSVERSE SECTION



SECTION OF THICKENED SLAB END

Showing PCP Option 1. Option 2 similar.

1. Place Bars 0A midway between Bars A at overhang.
2. Bars are continuous through joint.
3. Thickened slab end dimensioned perpendicular to face of bkwl, centerline interior bent or face of inverted-T stem.

HL93 LOADING — SHEET 1 OF 2

Texas Department of Transportation — Bridge Division Standard

GFRP SLAB TOP MAT REINFORCEMENT

PRESTRESSED CONC I-GIRDER SPANS

IGFRP

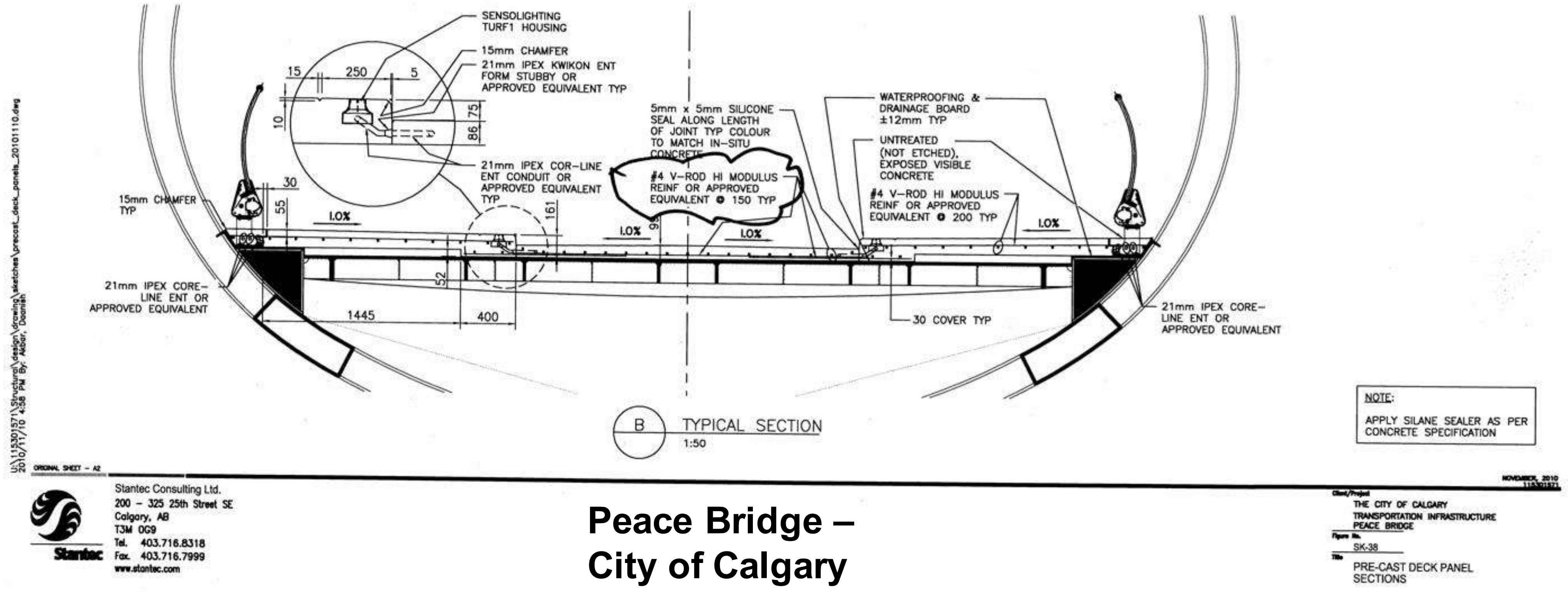
FILE: igfrs001-19.dgn	DN: TxDOT	CK: TxDOT	DW: TxDOT	CK: TxDOT
©TxDOT August 2017	CONT	SECT	JOB	HIGHWAY
REVISIONS	DIST	COUNTY		SHEET NO.

DATE:
FILE:

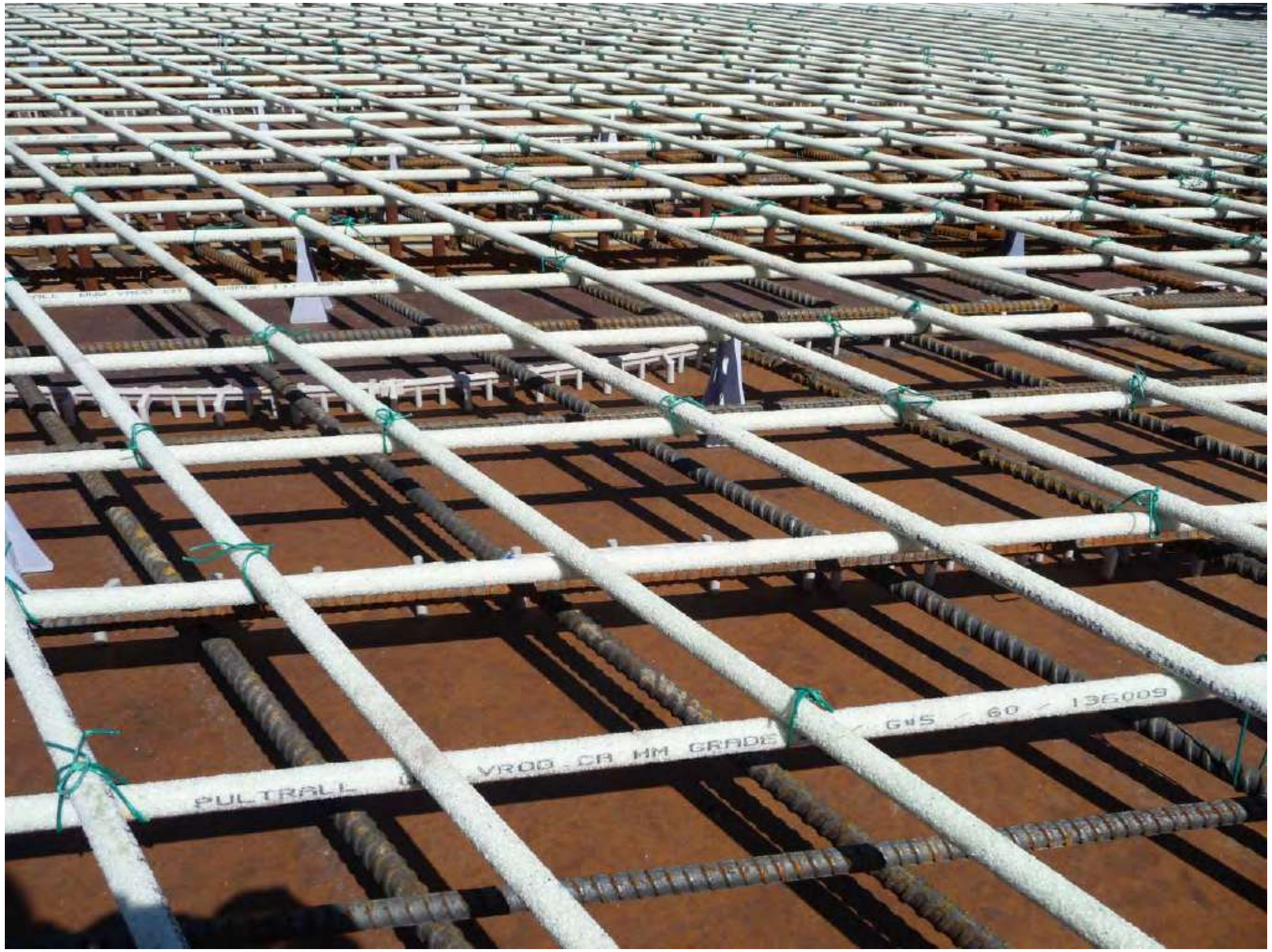
23rd Ave/Gateway Blvd –
Edmonton, AB
Deck bar ready for casting

MTO 2010-4004 rapid replacement

East Hamilton pedestrian bridge

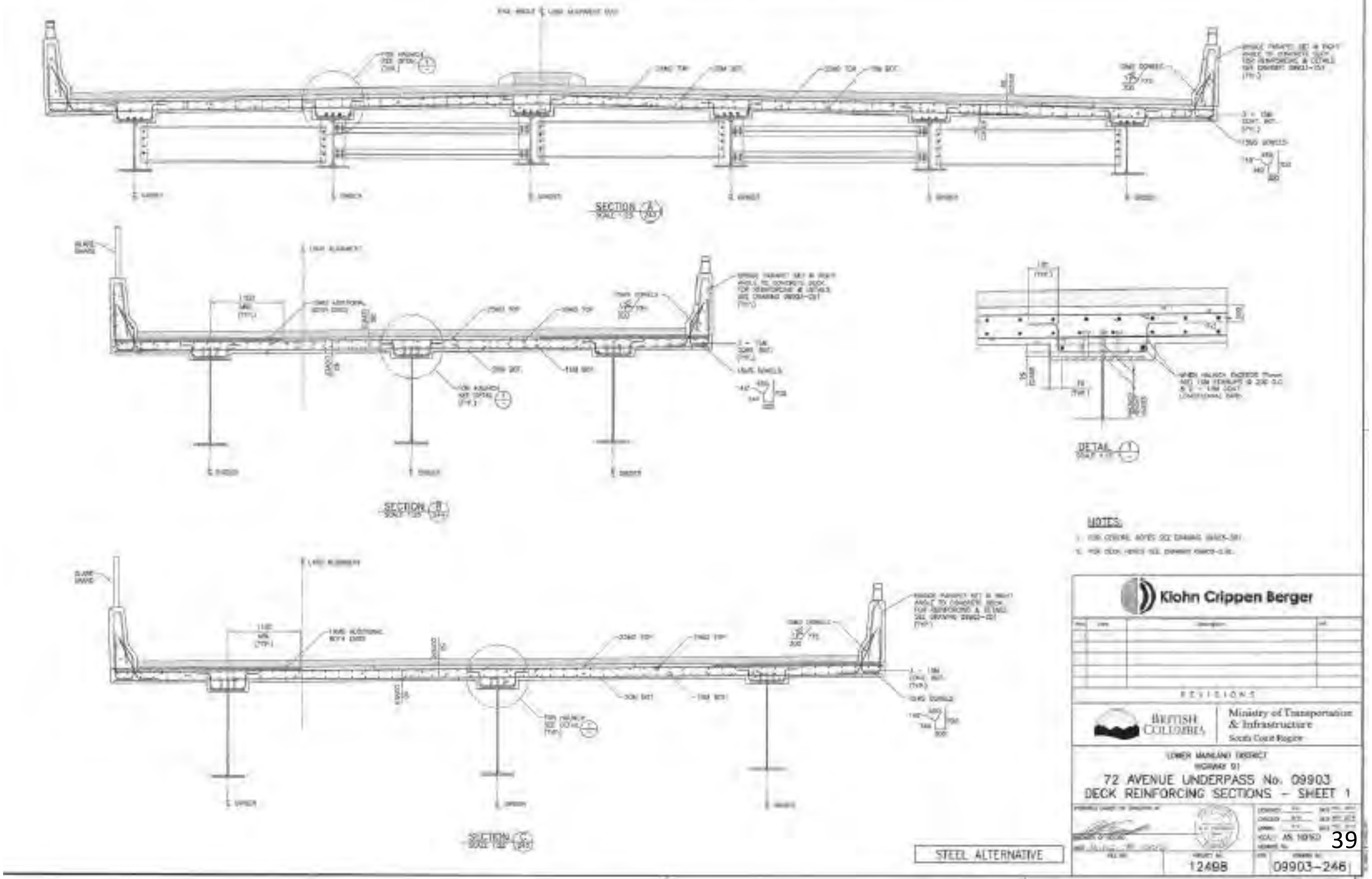


Peace Bridge – City of Calgary



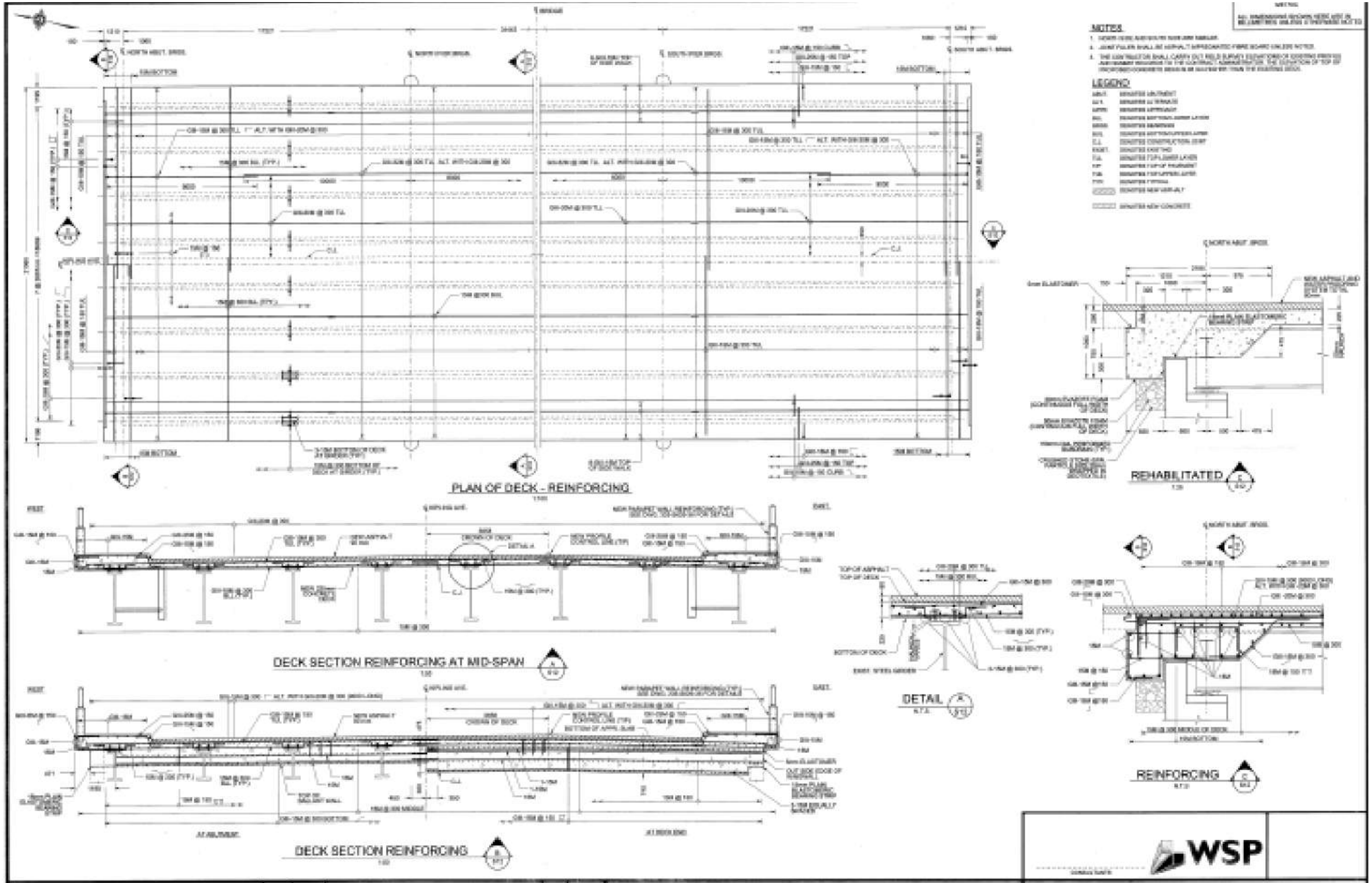
MTO 2012-4001 (Carling Av/Kirkwood Av overpass Rapidlifts, Hwy 417 in Ottawa, ON

MTO 2009-4726
(Beaver Creek)



SECTION A
SECTION B
DETAIL 1
SECTION C
NOTES:
Klohn Crippen Berger
REVISIONS
BRITISH COLUMBIA
Ministry of Transportation & Infrastructure
South Coast Region
LOWER MAINLAND DISTRICT
HIGHWAY 91
72 AVENUE UNDERPASS No. 09903
DECK REINFORCING SECTIONS – SHEET 1
SCALE: AS NOTED
STEEL ALTERNATIVE
12498
09903-246

Kipling Ave Bridge
City of Toronto
Designer - WSP



TORONTO Engineering & Construction Services

WSP

KIPLING AVENUE OVER THE HUMBER RIVER

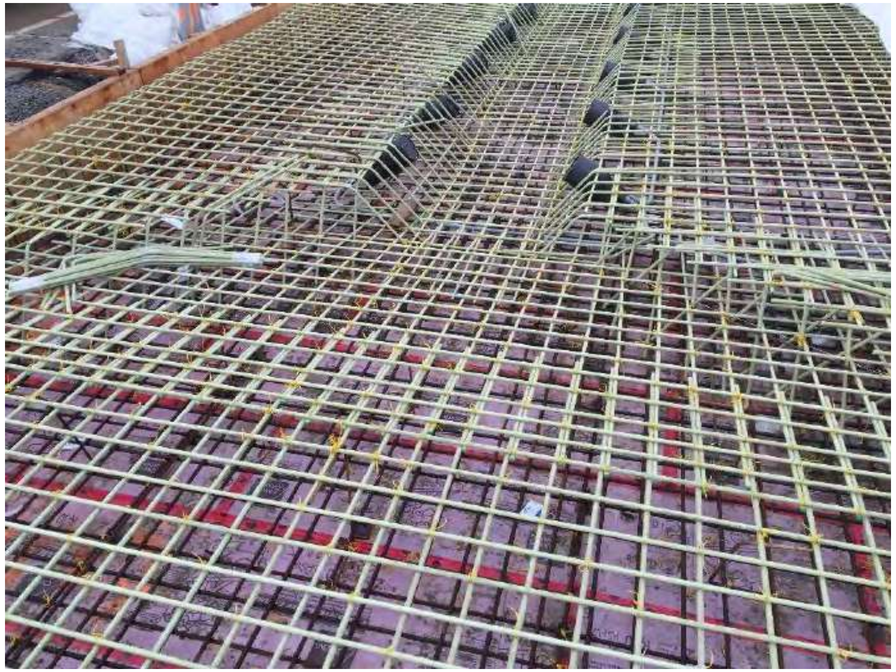
STRUCTURE REHABILITATION

DECK DETAILS

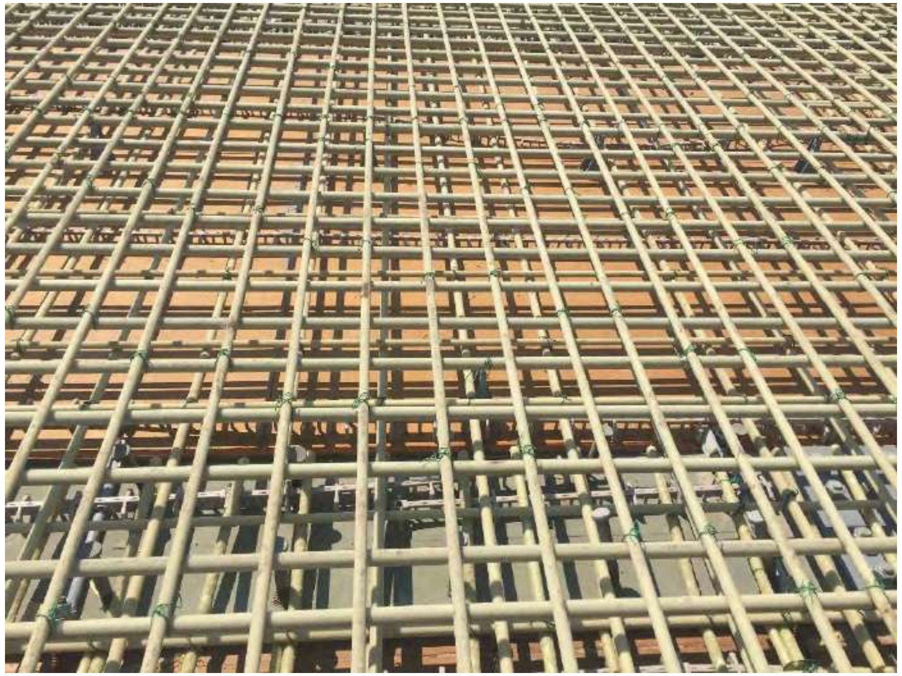
DRAWING NUMBER 325-S629-32

SHEET S12

Non-conductivity for cameras and sensors – tolling areas

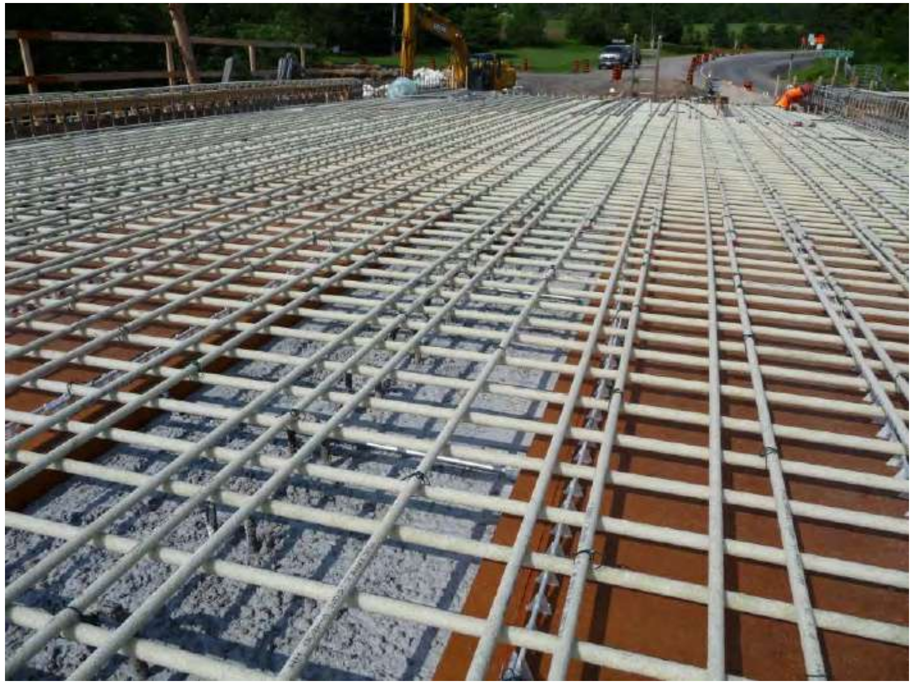


Rideau River Crossing
City of Ottawa
Designer – WSP
Contractor - Pomerleau



O’Reilly’s Bridge,
Niagara Region, ON

MTO 2009-5156



Rehabilitation

FIBEROX

Addington Av,
City of Toronto

Bridgeport Bridge,
Kitchener, ON


V·ROD
HILTI
Hilti.
Outperform.
Outlast

Bakers Haulover bridge - Florida

Pineda Causeway - Florida

MTO 2010-2054 (Warden Ave over Hwy 401 in Toronto - bar on site and placed in deck

Project Applications – Precast Decks

**Sunshine Creek- 2007,
MTO NW Region**

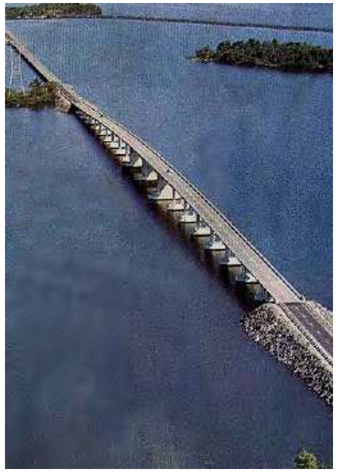
Pre-cast box girders

**Rainy Lake - 2006,
MTO NW Region**

Pre-cast panels decks

Noden Causeway, MTO NW Region

Pre-cast panels in place



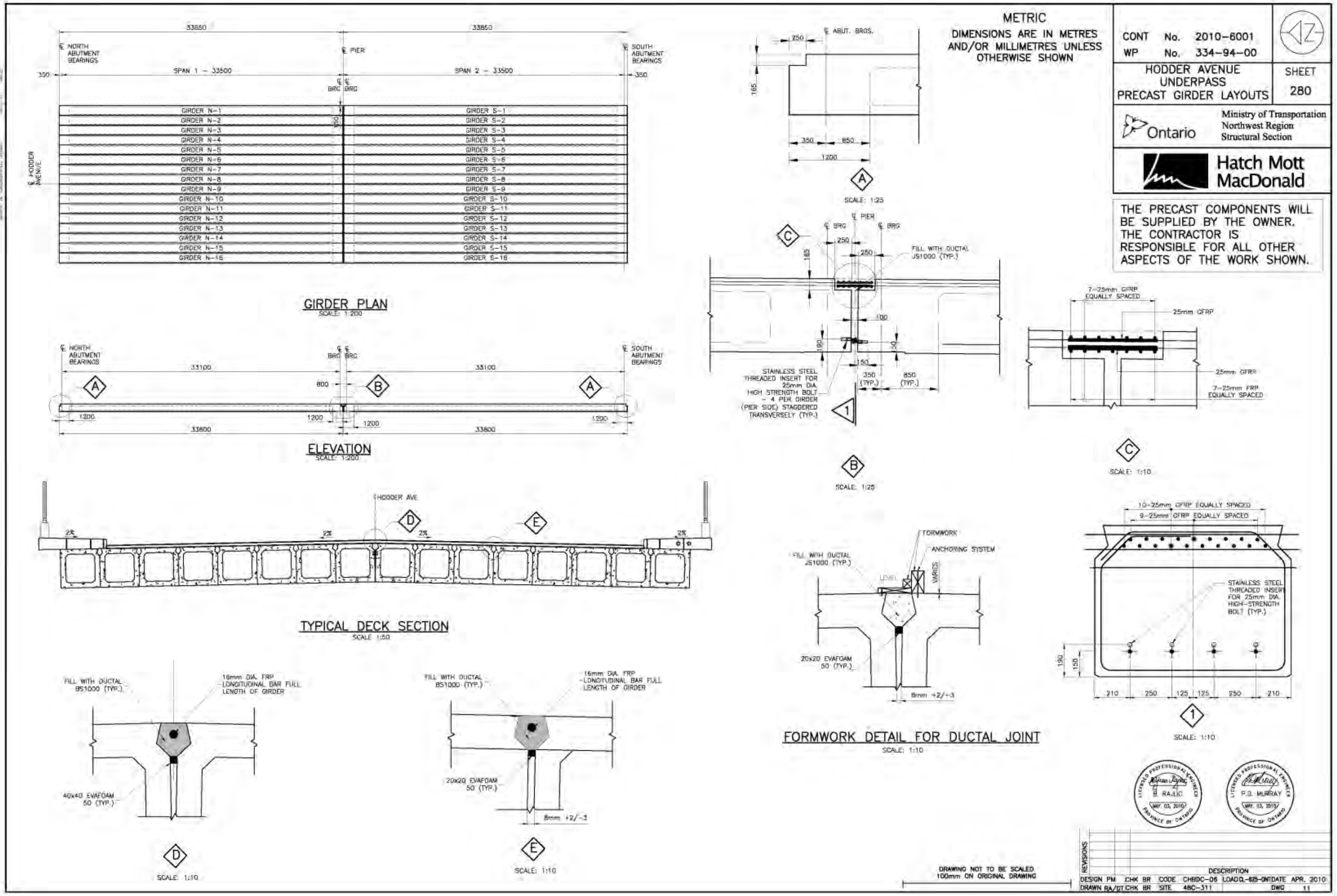

2008 8 13


2008 8 13


PC-1-1


17 07 2015

MTO 2010-6043
McKenzie River Bridge


METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN
CONT No. 2010-6001
WP No. 334-94-00
HODDER AVENUE UNDERPASS
PRECAST GIRDER LAYOUTS
SHEET
280
Ontario
Ministry of Transportation
Northwest Region
Structural Section
Hatch Mott MacDonald
THE PRECAST COMPONENTS WILL BE SUPPLIED BY THE OWNER. THE CONTRACTOR IS RESPONSIBLE FOR ALL OTHER ASPECTS OF THE WORK SHOWN.
GIRDER PLAN
SCALE: 1:200
ELEVATION
SCALE: 1:200
TYPICAL DECK SECTION
SCALE: 1:50
FORMWORK DETAIL FOR DUCTAL JOINT
SCALE: 1:10
SPAN 1 – 33500
SPAN 2 – 33500
NORTH ABUTMENT BEARINGS
SOUTH ABUTMENT BEARINGS
PIER
FILL WITH DUCTAL JS1000 (TYP.)
FILL WITH DUCTAL BS1000 (TYP.)
16mm DIA. FRP LONGITUDINAL BAR FULL LENGTH OF GIRDER
40x40 EVAFOAM 50 (TYP.)
20x20 EVAFOAM 50 (TYP.)
STAINLESS STEEL THREADED INSERT FOR 25mm DIA. HIGH STRENGTH BOLT (TYP.)
7-25mm GFRP EQUALLY SPACED
10-25mm GFRP EQUALLY SPACED
9-25mm GFRP EQUALLY SPACED
FORMWORK
ANCHORING SYSTEM
DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING
REVISIONS
DESCRIPTION
DESIGN PM CHK BR CODE CHBDC-06 LOAD CL-625-ONT DATE APR. 2010
DRAWN RA/GT CHK BR SITE 48C-311 DWG 11

Precast decks placed on Hodder Ave Bridge (MTO 2010-6001)

<u>Nipigon Cable Stayed Bridge</u>
Owner – ON Ministry of Transportation
Designer – MMM/WSP/ Buckland & Taylor
Contractor – BOT/Ferrovial
GFRP in all precast deck panels

Example of typical precast box girders, approach slabs and pre-stressed curbs
MTO 2014-6032

Chukuni River– MTO NW

Steel River– MTO NW

Hall’s River project
Florida DOT

<u>Flagler Beach</u>
Owner – Florida DOT
Designer – Mott MacDonald
Contractor – Malcolm Drilling
Supplied 19 flatbeds loads of material for secant pile cages