Third International Workshop on FRP Bars for Concrete Structures (IW-FRPCS3)

Workshop Theme: "Advances in concrete reinforcement"

Date: August 3-4th, 2021

DAY 1 Tuesday, August 3rd

Session 1: Owners Perspectives & Lessons Learned (8:15 - 10:00 am EDT)

(What do owners really want?)

RoundTable discussion with audience engagement, preceded by 5-minute introduction by panelists.

Moderator: Sam Fallaha (FDOT)

i. Case Study Projects *(5-minute presentations)*

ii. Implementation Policy and Results *(5-minute presentations)*

Panelists:

- Darrell Evans (PEI Transportation and Infrastructure)
- Zachary Haber (FHWA) No Slides
- Tim Keller (ODOT) No Slides
- Martin Krall (MTO)
- Marc-Antoine Loranger (MTQ)
- Chynoweth, Matthew (MDOT)
- Carroll, Trey (NCDOT)

THIRD INTERNATIONAL WORKSHOP ON FRP BARS FOR CONCRETE STRUCTURS

"Advances in concrete reinforcement"

August 3-4, 2021 - Virtual

Using ACM's for Internal Reinforcement in Prince Edward Island, Canada

Darrell Evans, P.Eng.

PEI Dept. of Transportation and Infrastructure

Canada

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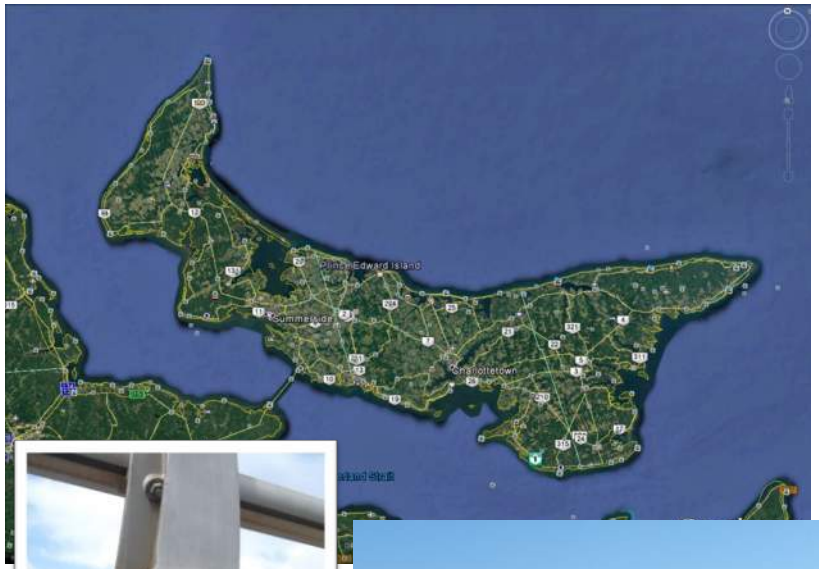
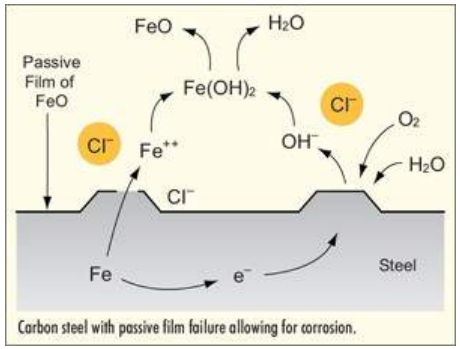


- Surrounded by salt water (about 34 ppt)
- Florida hovers around 36 ppt

Winter Maintenance

- Salt.
- Salt brine, salt pellets, salt/sand blend.
- Salt, salt, salt (NaCl).



Carbon steel with passive film failure allowing for corrosion.

Bridge	No. of Spans	Super structure	Horiz. Align.	Total Length (m)	Ft.
Monatgue Bridge	2	Steel Plate Girder	Curved	60	197
Clarks Mill	1	Steel Plate Girder	Curved	43	141
Montrose Bridge	1	Steel Box Girder	Curved	52	171
Victoria Bridge	1	Steel Plate Girder	Straight	33	108
Kildare Bridge	3	PCC NEBT Girder	Straight	57	187
West River	1	Steel Plate Girder	Straight	48	157
Oak Drive O/P	4	AASHTO Type III	Straight	59	194
Darnley Bridge	4	PCC NEBT Girder	Straight	137	449
Ross' Corner	1	Steel Box Girder	Curved	47	154
St. Peter's	1	PCC NEBT Girder	Straight	28	92
Cardigan	1	Pre-Cast Box Girder	Straight	24	79
Marie	1	PCC NEBT Girder	Skewed	26	85
Huntley	1	PCC NEXT Girder	Skewed	20	66
North Lake	3	PCC NEBT Girder	Curved and Skewed	75	246
Souris	4	PCC NEBT Girder	Straight	128	420
Cornwall Rd O/P	1	PCC NEBT Girder	Skewed	33	108
Clyde River	2	Steel Box Girder	Straight	132	433
Bannockburn Rd. O/P	1	PCC NEBT Girder	Curved and Skewed	35	115
New Haven Interchange	1	PCC NEBT Girder	Skewed	35	115
Hunter River	1	PCC Voided Slab	Straight	15	49
Oyster Bed	3	PCC NEXT Girder	Straight	42.3	139
		TOTAL DECK LENGTH		**1129.3**	**3705**

- Shaded areas represent deck and substructure.
- All others are just deck. T&B
- Represents about 7 % of bridge inventory.
- Plan on another 10 structures within the next 4 years.
- Green shaded is full-depth pre-cast deck post-tensioned together (albeit with steel).
- Orange is using GFRP ties (??) for the formworks.

- Recognize that it doesn't fit all scenarios.
- Pre-cast arches for example, use WWM which they can bend into any radius they require.
- Timber bridges (why bother)
- Retrofits or extensions.
- Also, where we require ductility (diaphragms or seismic)

Issues

- Designer inexperience (know your material – detailing – code limitations).
- Contractor inexperience (know your limitations – placement and cutting- UV degradation).
- Supplier resources (engineering and technical support for the end user - competitiveness).
- Repairs due to external damage.
- End of life disposal (sustainability)
- These are all solvable.

Thank you!

THIRD INTERNATIONAL WORKSHOP ON FRP BARS FOR CONCRETE STRUCTURS

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GFRP Bar Qualification
Ministry of Transportation Ontario (MTO)

Martin Krall MASc P.Eng, MTO, Canada

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- The MTO lists pre-qualified products (suppliers) on its Designated Sources for Materials (DSM) list
  - For use on MTO highway construction and maintenance contracts
  - Reduces risks for products that may involve time-consuming and/or expensive testing
  - Increase confidence that supplied product will be as specified in the construction contract
    - Product Acceptance/Approval is done at site on a per-project basis
- Qualification is:
  - Proof of capability of production of a specific product to standards from the specific facility listed
  - A baseline for later comparison with routine project testing
  - …not proof-of-concept

- Qualification of GFRP bars is done to:
  - DSM Structural Division Criteria for Approval, October 2018
  - CSA S807 "Specification for fibre-reinforced polymers"
  - MTO's active/current GFRP specification

- Qualification of GFRP bars requires a lot of testing
  - One grade of typical sizes of straight and bent bars tests 23 different properties using ~2500 individual specimens
    - 6 properties use conditioned specimens (thermal, alkali, etc.)
    - 8 require long-term commitments (creep-rupture, water absorption to saturation, most conditioned specimens)
  - Suppliers become qualified within 1 to 3 years
    - Done in stages; occasional product revision and re-testing

- MTO reviews qualification submissions for "completeness" and "correctness"
  - Completeness:
    - All required properties & samples (No. of specimens, production lots, etc.)
    - All "products" (straight, bent, anchor head, grades, etc.)
  - Correctness:
    - Proper test methods used
    - Results are reported correctly
    - Calculations performed correctly with appropriate parameters
    - Limits and standard values are calculated/reported/used correctly
    - Results meet the limits
  - Other rational checks
    - Does it make sense, is it realistic, is it consistent?

MTO Qualified Products

Current DSM is only Grade III GFRP Bars

- No other FRPs
- No other grades

Previous Qualifications

- Included Grade I
- Up to 7 suppliers

MTO Current DSM

- MST-Bar Straight & Bent
- V-Rod Straight, Bent, & Anchor-headed
- MateenBar Straight & Bent
- TUF-BAR (Edmonton) Straight & Bent

MTQ Department of materials contribution to GFRP bars implementation in Quebec

Third International Workshop on FRP Bars for Concrete Structures

Marc-Antoine Loranger, Eng.,
Ministère des Transports du Québec (MTQ), Canada
August 3, 2021

Votre gouvernement

Québec

MTQ CURRENT APPLICATIONS OF GFRP BARS

- More than 60 projects done with GFRP bars in the past 15 years.

Main uses

- Bridge deck slabs (top mat reinforcement with GFRP bars)
- Barrier walls
- Jointed plain concrete pavements (GFRP tie bars and dowels)
- Continuously reinforced concrete pavements
  - Few pilot projects

Votre gouvernement

MTQ IN-HOUSE LABORATORY

- Fully equipped laboratory to assess the performance and quality of GFRP materials.
- Able to conduct all the owner’s QA tests required by CSA S807.

MECHANICAL TESTING

- Longitudinal tensile properties
- Bond strength
- Transverse shear strength
- Strength of bent bars at bend locations
- Apparent horizontal shear strength
- Pullout capacity of anchor-headed bars

Votre gouvernement

PHYSICAL TESTING

- Cross-sectional area
- Fibre content
- Density
- Water absorption
- Cure ratio and glass transition temperature
- FTIR spectrometry
- XRF spectrometry

Votre gouvernement

MTQ DEPARTMENT OF MATERIALS ROLES AND CONTRIBUTION TO GFRP BARS IMPLEMENTATION

- Evaluation of new FRP products.
- QA testing of GFRP bars is taken in charge by the Department of materials.
- Case studies.
  - Example: Val Alain Bridge on Highway 20 East, Québec.
- Research and development in collaboration with universities and research centers.
  - Partners in the NSERC Industrial Research Chair in Innovative Fibre Reinforced Polymer (FRP) Composite Materials for Infrastructure.
- Active participation on national code committees such as CSA S807 and S808.
  - Numerous testing and evaluations done for the implementation of new technical requirements in materials standards.
- Defining materials specifications for MTQ design and providing on-site expertise during construction.

MTQ FOCUS AREAS FOR THE FUTURE

- Consider the use of FRP bars for other applications.
- Elaborate a MTQ standard for GFRP bars.
- Repair techniques for GFRP bars.
- Life-cycle cost analysis compared to galvanized or stainless steel bars.
- Long term durability of GFRP reinforcement compared to accelerated test models.
- Training for laboratories and practising engineers.

THANK YOU !
ANY QUESTIONS ?

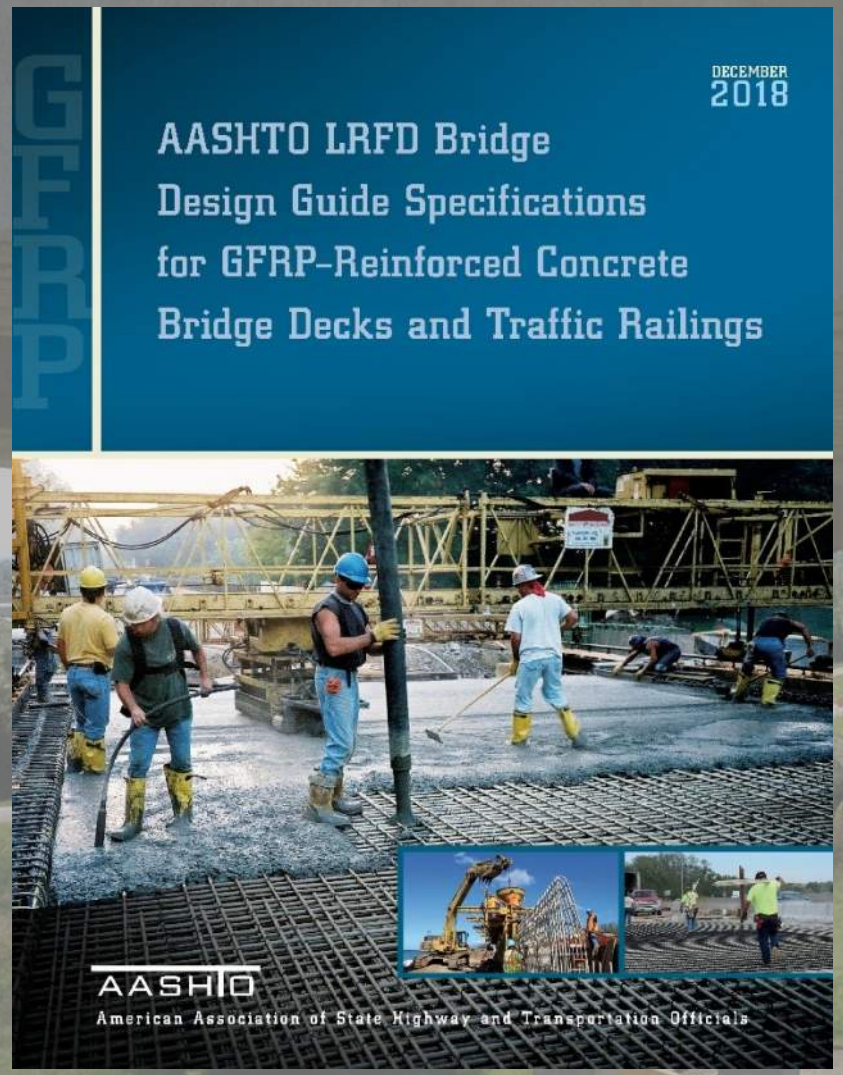
Contact me

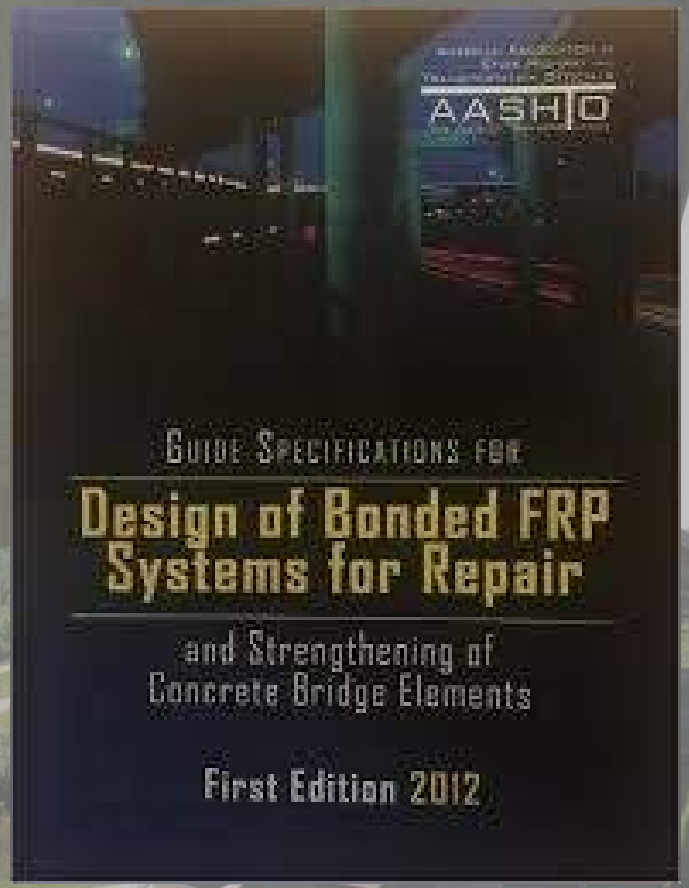
Marc-Antoine Loranger, Eng.

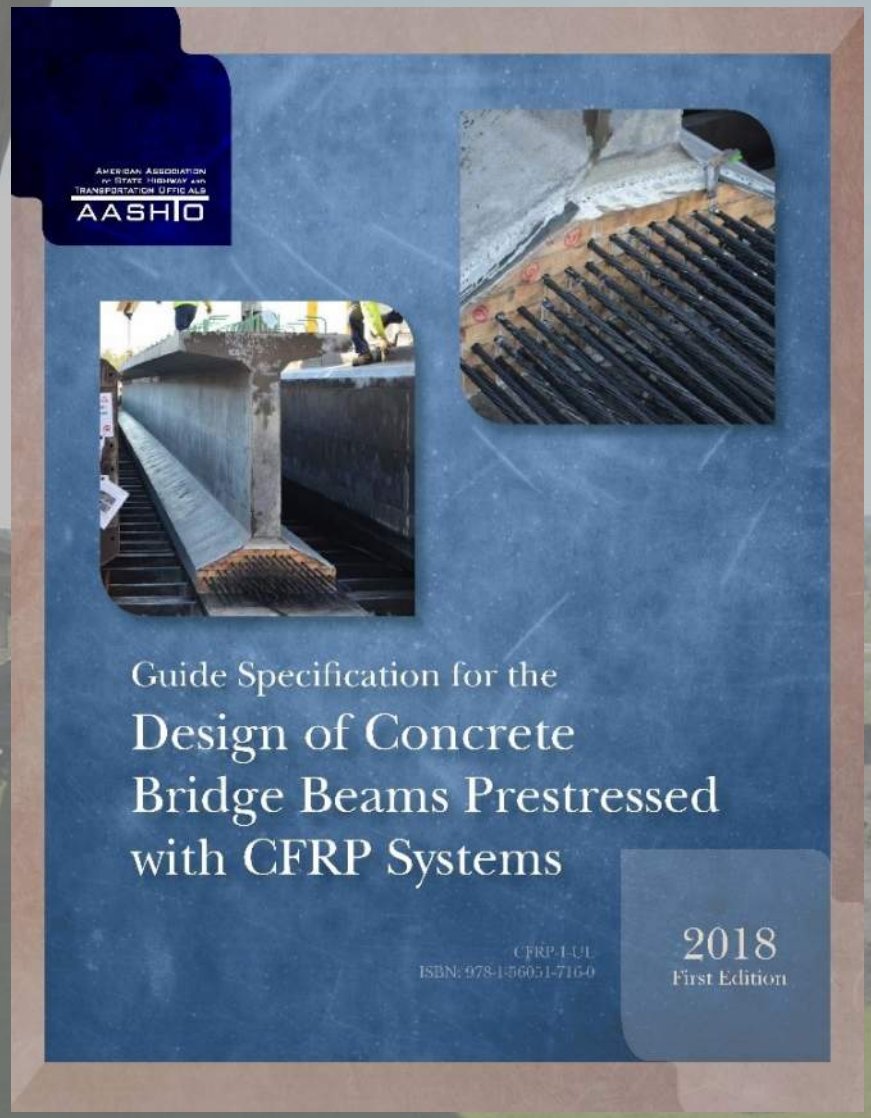
Ministère des Transports du Québec (MTQ)

✉ marc-antoine.loranger@transports.gouv.qc.ca

AASHTO Update







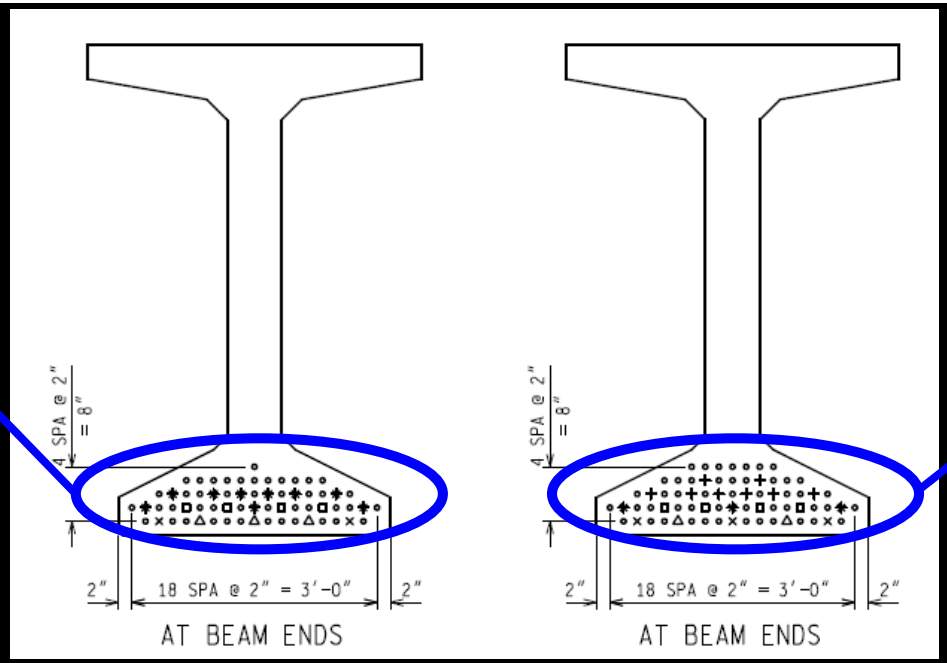
MDOT CFRP prestressing/post tensioning deployments

- Pembroke Ave over M-39 (2011)
- M-50 over NS Railroad (2012)
- M-102 EB and WB over Plum Creek (2013 – 2014)
- I-94 EB & WB over Lapeer Road (2014)
- M-100 over Sharp Drain (2015)
- M-66 over West Branch River (2015)
- M-86 over Prairie Creek (2016)
- I-75 SB over Sexton-Kilfoil Drain (2017)
- M-3 over I-94 (2018)
- Brush Street over I-94 (2019)
- **Burns Ave over I-94 (2021)**
- **Cadillac Ave over I-94 (2021)**

Prestressing of I-75 Bridge Beams

Other beams

63 strands
$\emptyset = 0.6$“



West fascia beam
(WFB)

69 strands
$\emptyset = 0.6$“

GFRP and BFRP mild reinforcement

20SP-802A-02

MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
CONCRETE CURB, AND GUTTER, WITH __ FIBER REINFORCED POLYMER, DETAIL __

STR:MJC 1 of 4 APPR:JAB:JFS:02-19-21
FHWA:APPR:03-05-21

a. Description. This work consists of constructing concrete curb, gutter, and dividers, using glass fiber reinforced polymer (GFRP), or basalt fiber reinforced polymer (BFRP) reinforcement in accordance with section 802 of the Standard Specifications for Construction, and as modified on the plans and this special provision. At the Contractors option the number 3 size GFRP or BFRP may be substituted for longitudinal epoxy coated number 4 conventional steel reinforcement shown on Standard Plans R-27 Series, R-30 Series, R-31 Series, and R-33 Series. Do not use GRFP or BFRP for lane ties, or any other transverse reinforcement.

b. Materials. Provide materials in accordance with subsection 802.02 of the Standard Specifications for Construction except as modified by this special provision. Furnish GFRP or BFRP reinforcement that meet the following material specifications and requirements. Provide GFRP or BFRP reinforcement in accordance with the details shown on the plans. Do not mix reinforcement types.

GRETCHEN WHITMER
GOVERNOR

STATE OF MICHIGAN
DEPARTMENT OF TRANSPORTATION
LANSING

PAUL AJEGBA
DIRECTOR

December 28, 2020

Mr. Matt Kero
Neuvokas Corporation, Gatorbar
3206 Number 6 Road
P.O. Box 220
Ahmeek, Michigan 49901

Dear Mr. Kero:

RE: Letter of Support – Glass Fiber Reinforced Polymer Reinforcement

The Michigan Department of Transportation will accept Glass Fiber Reinforced Polymer (GFRP) reinforcement as temperature and shrinkage reinforcement for non-structural applications.

Number 3 (3/8" diameter) size GFRP bars may be substituted for longitudinal number 4 conventional steel reinforcement shown on Standard Plans R-27 Series, R-30 Series, R-31 Series, and R-33 Series.

GFRP must meet the following minimum requirements:

Reference	Property	Unit	#3 Bar Properties
ASTM D2584	Fiber Content by Mass	%	80
ASTM E1640	Mean Glass Transition Temperature (DMA)	°F	200
ASTM D792	Mean Measured Cross-Sectional Area	in^2	0.112
ASTM D7205	Guaranteed Ultimate Tensile Force	kip	17.1
	Nominal Ultimate Tensile Strength	ksi	160
	Nominal Mean Tensile Modulus of Elasticity	Msi	6.5
	Nominal Mean Tensile Strain	%	2.5
ASTM D7705-A	Alkaline Resistance: Tensile Load Retention	%	81
ACI 440.3R-12	Mean Bond Strength	ksi	1.5
ASTM D7617	Mean Transverse Shear Strength	ksi	22
ASTM D570	Mean Moisture Absorption of 24 hours	%	0.5
ASTM D5229	Mean Moisture Absorption at Saturation	%	0.23

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LH-LAN-0 (01/19)

THIRD INTERNATIONAL WORKSHOP ON FRP BARS FOR CONCRETE STRUCTURS

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NCDOT & FRP Rebar

Trey Carroll, P.E., North Carolina Department of Transportation, USA

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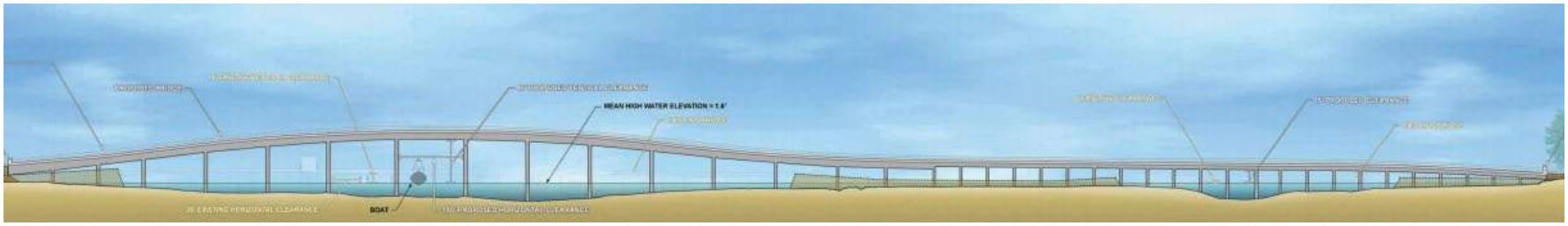
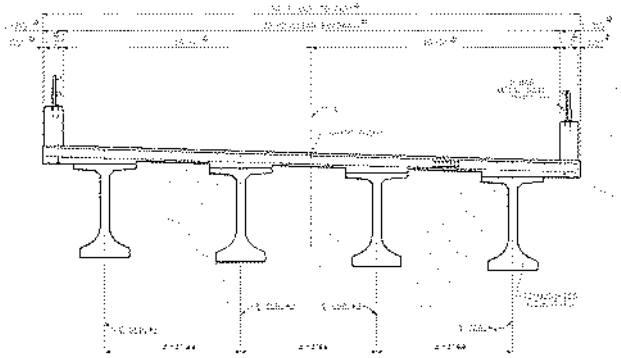
NCDOT Experience

- 2005 – Glass Fiber Reinforced Polymer (GFRP) Bridge Decks
- 2014 – NCDOT/NCSU Research Project 2014-09: *CFRP Strands in Prestressed Cored Slab Units*
- 2017 – Transportation Pooled Fund Research Project – 5(363): *Evaluation of 0.7 inch Carbon Fiber Reinforced Polymer Pretensioning Strands in Prestressed Beams*



Proposed Structure: 3,200'-0"
28 Spans



Harkers Island Bridge Project Details

- Cast-in-place Concrete (Superstructure* & Substructure)
  - Glass Fiber Reinforced Polymer (GFRP) Bars
- Prestressed Concrete Girders
  - Carbon Fiber Reinforced Polymer (CFRP) Strands
  - GFRP Stirrup Option
  - CFRP Stirrup Option
- Prestressed Concrete Piles
  - CFRP Strands
  - CFRP Spiral

Harkers Island Bridge Project Detail

- Construction Bid: $60,000,000
- FHWA AID Commitment: $1,000,000
- CFRP Prestressing Strand:
  - Girders: 650,000 Linear Feet
  - Piles: 325,000 Linear Feet
- GFRP Reinforcement:
  - Superstructure: 715,000 Linear Feet
  - Substructure: 200,000 Linear Feet