CFRP Applications in Michigan
&
AASHTO Innovations Initiative Program

2015 AASHTO Subcommittee on Construction

Mark Chaput - Bureau of Field Services

August 11, 2015

CFRP Applications in Michigan

- Internal Reinforcement and Pre-stressing strands in concrete beams
- Post Tensioning for Concrete Box Beams

What is A.I.I.?

- AASHTO Innovation Initiative
  - Formerly AASHTO TIG
  - Innovation by transportation agencies, for transportation agencies
  - Leading edge, not bleeding edge
  - Agency teams that developed and proved the concepts

Lead States Team

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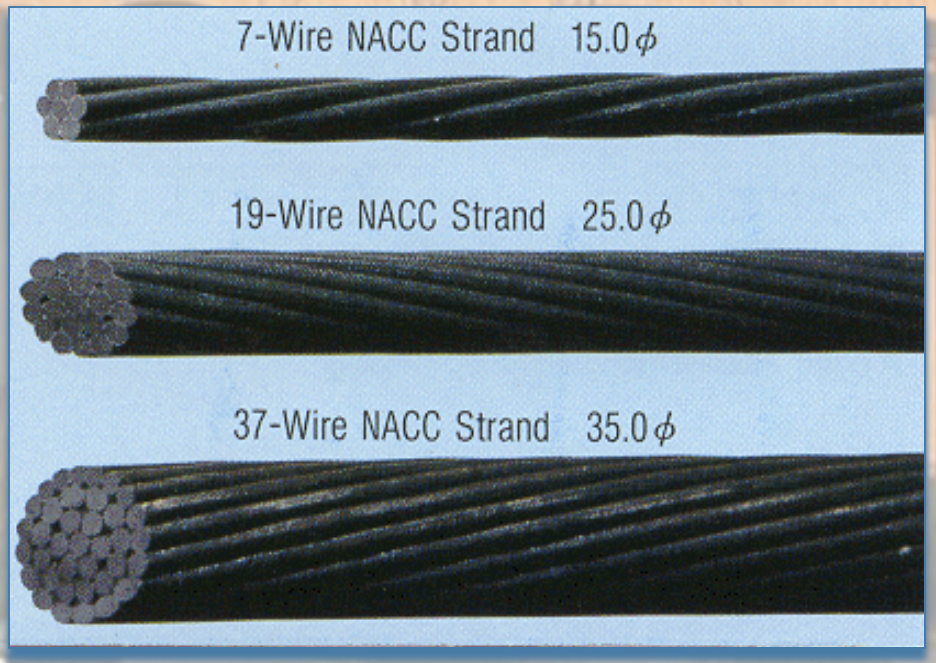
Why Consider CFRP

- Ensuring appropriate investment and longest service life using public transportation dollars
- Advancing innovative materials in the pursuit of the 100-year service life bridge
- Fostering economic development by using innovative materials

Research History

- MDOT has been partnering with Lawrence Technological University on CFRP research
- Material specifications, standard details, stressing procedures and tolerances



Advantages of pre-stressing

- Higher ultimate stressing strength
- Non-corrosive
- Lightweight
- Similar construction processes as steel alternatives

- Failure warning characteristics

Advantages of post-tensioning

- Higher ultimate stressing strength
- Lightweight
- Non-corrosive
- No grout is required for duct

- Ability to re-tension if necessary
- Rehabilitation and maintenance options

Michigan DOT Deployments

FY	REGION	LOCATION	BRIDGE ID	TECHNOLOGY DESCRIPTION	COMMENTS
2001	Southfield	Bridge Street over Rouge River	B01 of 63-20-35	Full superstructure	First in the US
2011	Metro	Pembroke Ave over M-39	S09-82193	Deck reinforcement and post tensioning	803 feet of 40 mm cable used
2012	University	M-50 / US-127 BR ov RR	R01-38072	post tensioning	1017 feet of 40 mm cable used
2013	Metro	WB M-102 over Plum Creek	B03-82141-4	Deck reinforcement, pre-stressing, shear stirrups	106,000 feet of 15.2 mm cable used
2014	Metro	EB M-102 over Plum Creek	B03-82141-3	Deck reinforcement, longitudinal pre-stressing, shear stirrups	106,000 feet of 15.2 mm cable used
2014	Metro	I-94 EB over Lapeer Rd	S18-77111-3	Post tensioning	861 feet of 40 mm cable used
2015	Metro	I-94 WB over Lapeer Rd	S18-77111-4	Post tensioning	861 feet of 40 mm cable used
2015	University	M-100 over Sharp Drain	B02-23071	Longitudinal pre-stressing	10,000 feet of 15.2 mm cable to be used
2015	North	M-66 over West Branch River	B01-67032	Longitudinal pre-stressing	5200 feet of 15.2 mm cable to be used
2016	Southwest	M-86 over the Prarie River	B01-78061	Longitudinal pre-stressing for decked bulb-T beam	Potential candidate, structure study complete, still evaluating

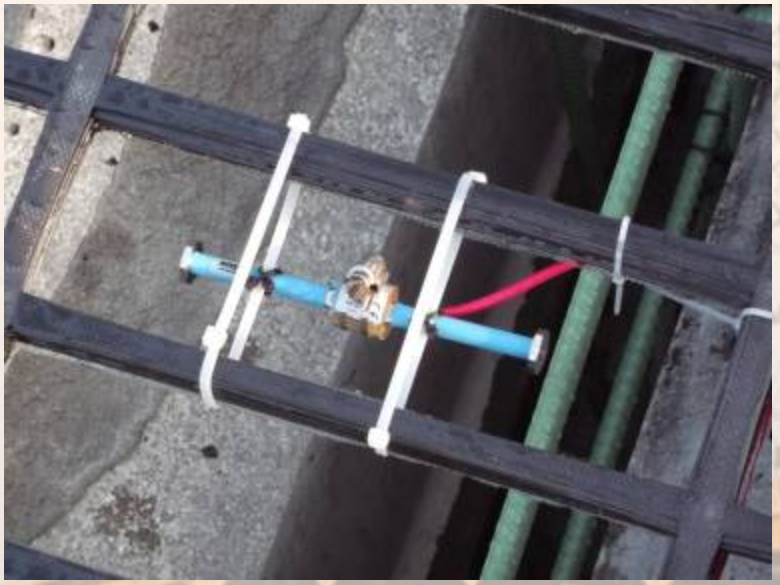
MDOT CFRP Deployment - 2011

Pembroke over M-39 Superstructure Replacement

MDOT CFRP Deployment

MDOT CFRP Deployment

MDOT CFRP Deployment



MDOT CFRP Deployment - 2012

M-50/US-127 BR over NS RR Bridge Replacement

MDOT CFRP Deployment

MDOT CFRP Deployment

MDOT CFRP Deployment

MDOT CFRP Deployment

Tokyo Rope Mfg.
May 28, 2012

3. CFCC Inspection

Classification Inspection of CFCC 1×37 40.0φ and Transverse Post-Tensioning Cable equivalent
Particular Breaking load of CFCC and Transverse Post-Tensioning Cable equivalent
Date May 28, 2012
Specimen details CFCC 1×37 40.0φ Transverse Post-Tensioning Cable equivalent 3.8m long including terminal fixing by stainless steel sockets; 1pc

Results

Specimen	Lot No. of CFCC	Breaking load		Others
		Specification	Measured	
CFCC 1×37 40.0φ Transverse Post-Tensioning cable equivalent	G56	1,200 or above	2,173.6 kN	-

Witnessed by Dr. Nabil F. Grace, Lawrence Technological University

(signature) 05/28/2012

Mr. Takuji Yoshimoto, Plant Manager, Gamagori CFCC Plant, TCT Division

(signature)

Gamagori CFCC Plant, Tokyo Rope Mfg. Co., Ltd.

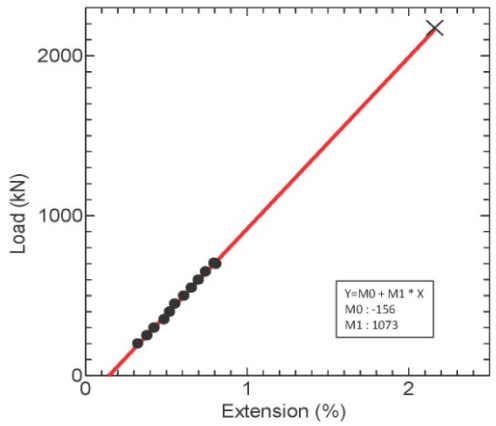
Tokyo Rope Mfg. Co., Ltd. Gamagori CFCC Factory 1-1 Nakamura Toyooka Gamagori Aichi 443-0011 Japan Phone +81-533-68-3176 Fax. +81-533-68-0882

Tokyo Rope Mfg.
May 28, 2012

Tensile Test Result

CFCC Inspection – 40.0 φ
Specimen : No. P-1
(CFCC 1×37 40.0φ)
Transversa Post-Tensioning Cable equivalent

Load-extension curve



Braking Load =	2173.6 kN
Effective cross sectional area =	798.7 mm^2
Tensile modulus =	134 GPa
Elongation at break =	2.2 %

Tokyo Rope Mfg. Co., Ltd. Gamagori CFCC Factory 1-1 Nakamura Toyooka Gamagori Aichi 443-0011 Japan Phone +81-533-68-3176 Fax. +81-533-68-0882

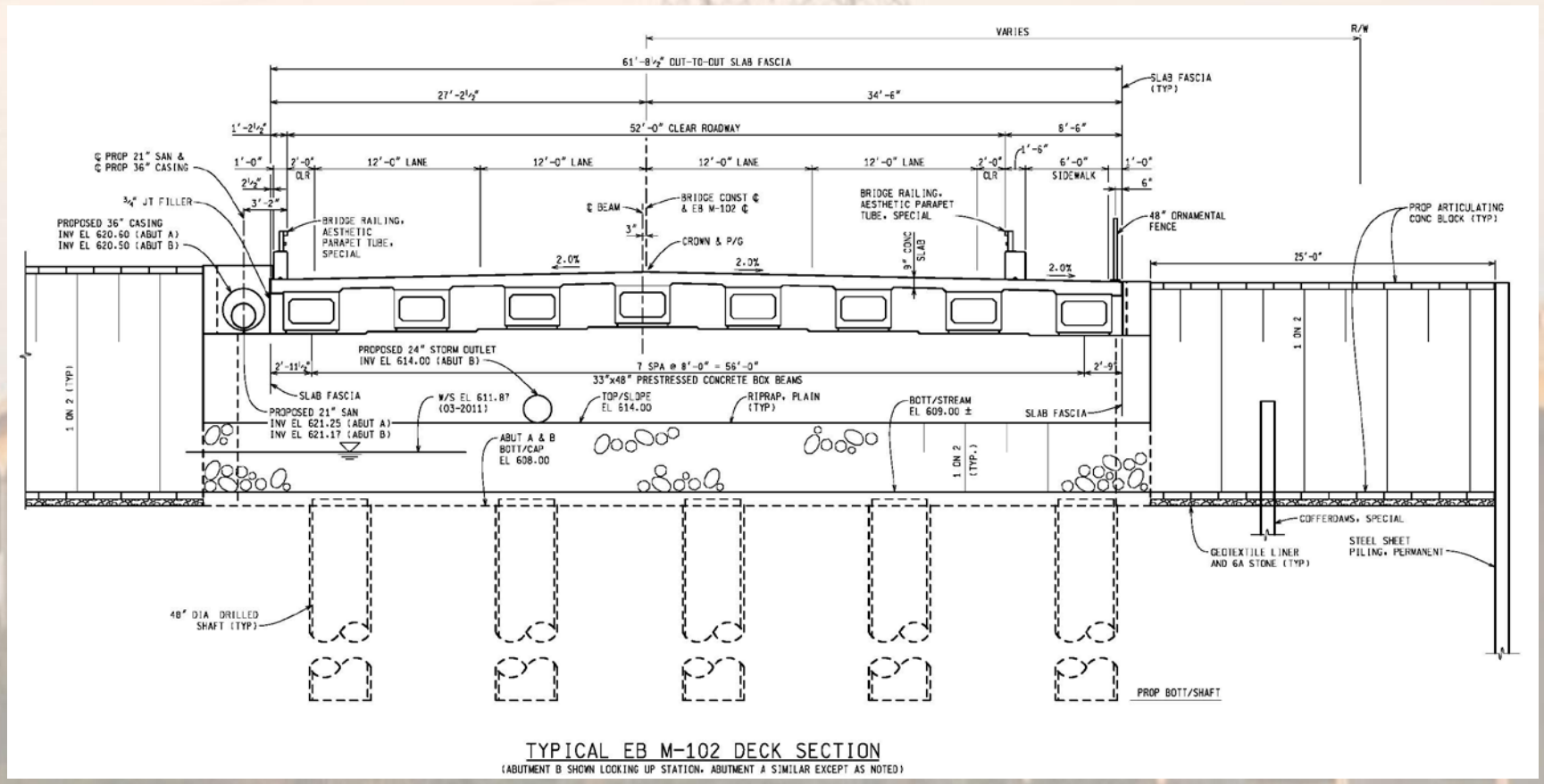
1200 kN = 269 kips
2173 kN = 489 kips

Taking the next step

- After successful deployments of CFRP materials on two projects, MDOT decided in 2013 to move forward with a prestressed application
- MDOT selected an M-route structure with easy access to monitoring equipment, and inspection
- This route takes 4 lanes in each direction in and out of the City of Detroit, and has a very high ADT

Taking the next step – M-102 over Plum Creek City of Detroit

Design Factors



TYPICAL EB M-102 DECK SECTION

(ABUTMENT B SHOWN LOOKING UP STATION, ABUTMENT A SIMILAR EXCEPT AS NOTED)

M-102 over Plum Creek: Design Factors

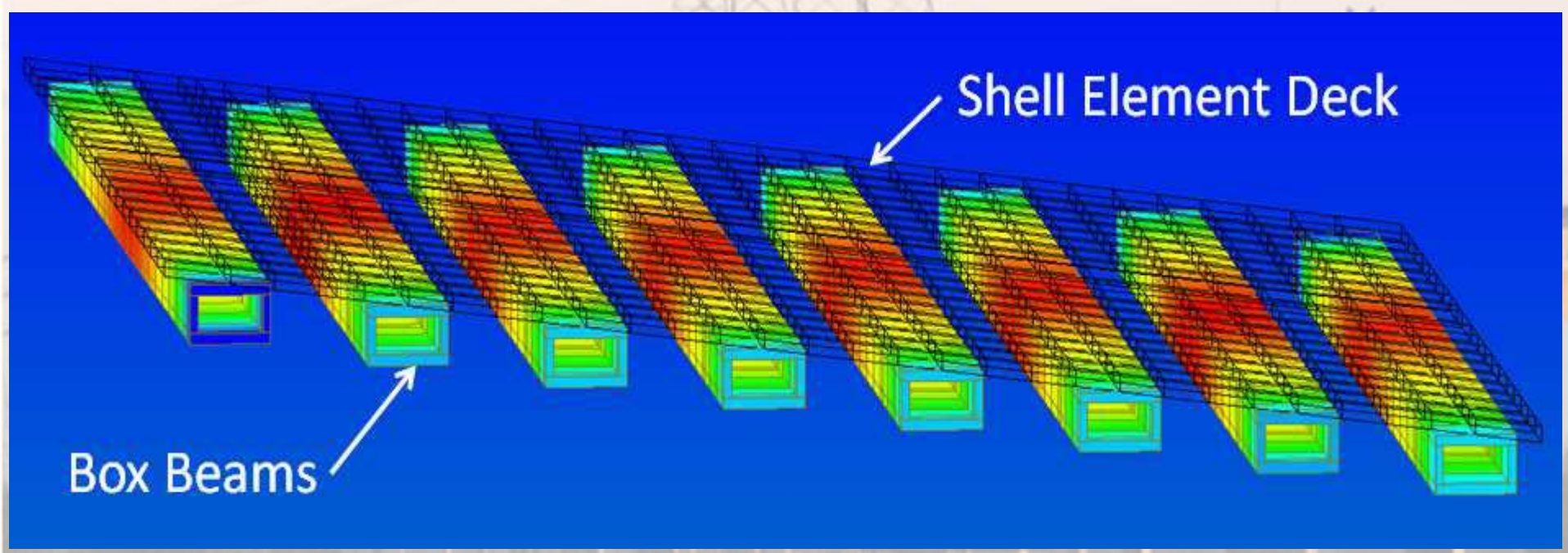
CFRP strand data based on testing:

- *GUTS* = 60.70 kips
- A_{strand} = 0.179 in^2

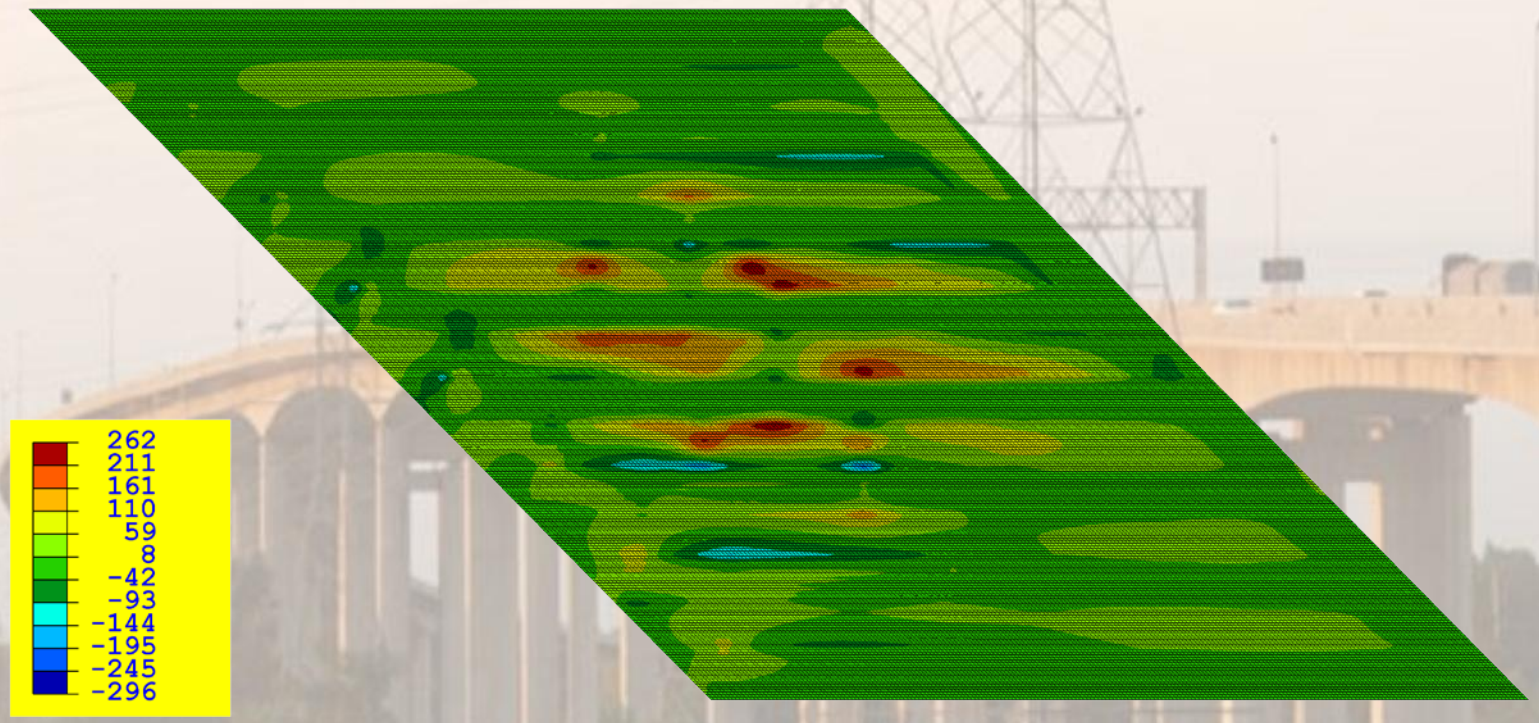
- f'_{pu} = 339 ksi – calculated ultimate tensile strength
- C_E = 0.90 – environmental factor per ACI 440.1R-06
- f_{pu} = 305 ksi – design ultimate tensile strength

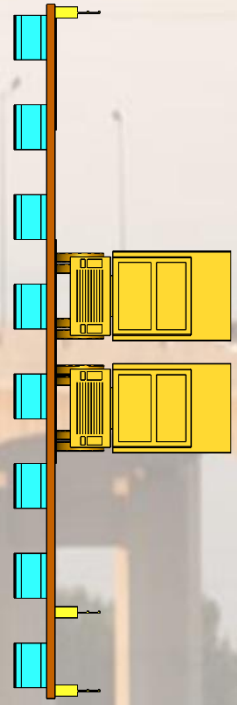
- E_{ps} = 21,000 ksi*

M-102 over Plum Creek: Design



M-102 over Plum Creek: Design





M-102 over Plum Creek: Challenges

Beam Fabrication:

- Estimating enough contract quantities of CFRP cable accounting for waste generated during pre-stressing
- CFRP coefficient of thermal expansion different from that of steel – must take into consideration pre-stressing bed contraction and expansion
- Coupling the CFRP strands to steel added time to the fabrication process.

Construction:

- Tying the deck mat was time consuming.
- Special storing and handling requirements for CFRP materials

M-102 over Plum Creek: Fabrication

M-102 over Plum Creek: Fabrication

M-102 over Plum Creek: Fabrication

M-102 over Plum Creek: Fabrication

M-102 over Plum Creek: Construction

MDOT CRFP Implementation in Summary

- The benefits of using these materials is the non-corrosive properties, and eliminating the need to grout post-tensioning ducts

- Analysis shows a potential 60% reduction in overall life cycle costs compared to bridges that use traditional steel reinforcement for the pre-stressing and post-tensioning materials.

A-II Activities

- Peer exchanges, informational webinars
- Website for shared resources
- Technical assistance (Limited-time)
- Activities Funded by States through AASHTO

AII Marketing Approach

- Two pronged strategy:
  - General information for agencies interested in specifications and standards, and wanting more information
  - More detailed technical design and construction support for agencies considering implementation

AII Marketing Resources

- Sample designs, sample plans, material specifications posted on AII CFRP website
- Deploy other technical resources and develop workshops and webinars to assist agencies in early stages of implementation
- Engage other groups, such as AASHTO SCOC, and SCOM

Lead States Team Deployments

- VDOT – using CFRP prestressed piles, and prestressed bulb-T beam superstructure
- ODOT – using CFRP for pre-stressed bulb-T beam superstructure
- Maine DOT – using CFRP pre-stressed I-beam superstructure
- Caltrans – using CFRP surface and near surface mounted wraps for superstructure strengthening

AASHTO Innovation Initiative

AASHTO

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- Additionally Selected Technologies
- AII Solicitation
- Lead States Team Support

Carbon Fiber Reinforced Polymer Strands

AASHTO > AASHTO Innovation Initiative > Carbon Fiber Reinforced Polymer Strands

What are CFRP Strands

CFRP is a corrosion-free option for pre-tensioning and post-tensioning applications on concrete elements.
More >>

Hand-Outs | Additional Resources | Contacts

Thank You !

Questions?