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

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

Classification: Inspection of CFCC 1 x 37 40.0øp and Transverse Post-Tensioning Cable equivalent

Perticular: Breaking load of CFCC and Transverse Post-Tensioning Cable equivalent

Date: May 28, 2012

Specimen details: CFCC 1 x 37 40.0øp Transverse Post-Tensioning Cable equivalent 3.8m long including terminal fixing by stainless steel sockets; 1pc

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Lot No. of CFCC</th>
<th>Breaking load</th>
<th>Others</th>
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<tr>
<td>CFCC 1 x 37 40.0øp</td>
<td>005</td>
<td>1,200 kN above</td>
<td>2,173 kN</td>
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<tr>
<td>Transverse Post-Tensioning cable equivalent</td>
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</tbody>
</table>

Witnessed by Dr. Natoli F. Giaco, Lawrence Technological University

[Signature]

05/2012

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

[Signature]

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

Tensile Test Result

CFCC Inspection - 40.0 øp

Specimen No.: P-1

CFCC: 1 x 37 40.0øp

Transverse Post-Tensioning Cable equivalent

Load-extension curve

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
M-102 over Plum Creek: Design Factors

CFRP strand data based on testing:

- $GUTS = 60.70$ kips
- $A_{stran(d} = 0.179$ 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

Shell Element Deck

Box Beams
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: 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
All 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
All Marketing Resources

• Sample designs, sample plans, material specifications posted on All 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
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?