CFCC Update

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Tokyo Rope and Tokyo Rope USA
## CFCC projects in the United States

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<th>construction</th>
<th>application</th>
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<td>6 North Carolina DOT</td>
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### FRP for New Construction
CFCC Plant in the United States

Production start in September 2016
# Table of Contents

I. What is CFCC?  
II. Application of CFCC  
III. Benefit of CFCC
I. What is CFCC?

- CFCC is Carbon Fiber Composite Cable.
- CFCC is a stranded CFRP. \(\rightarrow\) FLEXIBLE
- CFCC consists of PAN (Polyacrylonitrile) based continuous carbon fibers, with epoxy resins used as a binding material.

\(\rightarrow\) LIGHT WEIGHT

- CORROSION FREE
- HIGH TENSILE FATIGUE PERFORMANCE

\(\rightarrow\) HIGH TENSILE STRENGTH

- HIGH TENSILE MODULUS
Type of CFCC

- **Tendon**
  - Pre-tensioning cables
  - Post-tensioning cables

- **Non-prestressing reinforcement**
  - Bars
  - Stirrups
  - Spirals
I. What is CFCC?

Reinforcement bars or Pre-tensioning cables

Post-tensioning cables
I. What is CFCC?

Stirrups

Spirals
I. What is CFCC?

CFCC REINFORCEMENT CAGE → Light weight

Easy to carry around by people
I. What is CFCC?

Anchoring systems of CFCC

For Pre-tensioning

- Sleeve
- Buffer material
- Wedges

For Post-tensioning

- Steel sleeve
- Highly Expansive Material
- CFCC
New wedges

• Developing the New wedges for pre-tension and
• Post-tension
Table of Contents

I. What is CFCC?

II. Application of CFCC

III. Benefit of CFCC
There are about 200 applications. (by 2017)
### Application of CFCC

<table>
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<tr>
<th>No.</th>
<th>Category</th>
<th>Number of Application</th>
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<tr>
<td>1</td>
<td>Concrete Structures (Reinforcement)</td>
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<tr>
<td>2</td>
<td>Cable for Bridges (Stay or Main Cable)</td>
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<td>3</td>
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<td>4</td>
<td>Other</td>
<td>14</td>
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<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>198</strong></td>
</tr>
</tbody>
</table>
(1). **Concrete Structures** (Pre-tensioning)

Shinmiya Bridge  **1988.10** in Japan

**World’s first** PC bridge using CFRP tendon

*Sea of Japan*

*Fuki chou, Ishikawa, JAPAN*
Former Bridge

[After-construction 20 years]
New Shinmiya Bridge

Sea of Japan

Pre-tensioned PC slab bridge
Bridge length: 6.1 m
Overall width: 8.2 m

CFCCs are used for pre-tensioning tendons.

FRP for New Construction
Quantity of chloride ion in the concrete beam

New Shinmiya Bridge

[After-construction 23 years]

CFCC position from the surface

1.2 kg/m³ Rust generating limit of steel

Depth from the concrete surface (cm)

Quantity of chloride ion (kg/m³)
Former Bridge  [After-construction 20 years]

New Shinmiya Bridge  [After-construction 23 years]

FRP for New Construction
(2). Concrete Structures (Post-tensioning)

Bridge Street Bridge  May. 2001  in Southfield, Michigan

Funded by FHWA and MDOT  United States’s first bridge constructed using CFRP

- TPT
  - CFCC 1x37 40.0φ: 9.2 m x 10 tendons,
  - 9.4 m x 7 tendons
  - CFCC 1x19 21.8φ: 9.0 m x 6 tendons

- External Tendons
  - CFCC 1x37 40.0φ: 16.8 m x 24 tendons,
  - 17.0 m x 30 tendons

Transverse Cables

External Cables

CFCC 1x37×40 (Post-tensioned material, exterior cable)
(3). **Concrete Structures** (Pre-tensioning & Deck Reinforcement)

**M-102 over Plum Creek**  **Jun. 2013**  **in Michigan**

- **Deck Reinforcement** CFCC $1 \times 7 \ 15.2\phi$

- **8 beams × 2 bridges = 16 beams**

- **4’ × 2’-9” Box beam**
- 37 strands: CFCC $1 \times 7 \ 15.2\phi$
- Stirrups: CFCC $1 \times 7 \ 15.2\phi$
- Top rebar: CFCC $1 \times 7 \ 15.2\phi$

**FRP for New Construction**
FRP for New Construction
(4). Concrete Structures (Pre-tensioning)

RTE. 49 Bridge over Aaron’s Creek (Bulb-T beam)

Jun. 2015 in Virginia

48 strands - CFCC 1×7 15.2φ

Stirrups - CFCC 1×7 15.2φ, CFCC 1×7 17.2φ

Bridge Length: 168’ – 10”
Bridge Width: 32’ - 4”

48 strands × 8 beams

FRP for New Construction
(5). **Concrete Structures** (Pre-tensioning)

Innovation Bridge (Hecht Athletics Pedestrian Bridge)

Oct. 2015 in Miami

Bridge Length: 70’ – 0”
Bridge Width: 14’ – 3”

18 strands × 2 beams
(6). Concrete Structures (Pre-tensioning)
Other beams

63 strands

West fascia beam (WFB)

69 strands

AT BEAM ENDS

AT MID-SPAN

INTERIOR BEAMS B–J
MEDIAN FASCIA BEAM K
STRAND LOCATIONS

+ DEBOND 6 FT EACH END
★ DEBOND 8 FT EACH END
◆ DEBOND 12 FT EACH END
▲ DEBOND 16 FT EACH END
✖ DEBOND 20 FT EACH END

+ DEBOND 3 FT EACH END
★ DEBOND 22 FT EACH END
◆ DEBOND 15 FT EACH END
▲ DEBOND 28 FT EACH END
✖ DEBOND 6 FT EACH END
FRP for New Construction
(7). **Concrete Structures** (Post-tensioning)

**I-94 Bridge over Lapeer Rd.**  
Jun. 2015  
in Port Huron, Michigan

- **East bound (14 box beams)**
  - Bridge Length: 164’ – 0”
  - Bridge Width: 57’ – 7.5”

- **West bound (15 box beams)**
  - Bridge Length: 164’ – 0”
  - Bridge Width: 61’ – 9”

**TPT CFCC 1×37 40.0φ**

East bound: 59’ - 2” (18.0 m) × 20 tendons
West bound: 63’ – 3.5” (19.3 m) × 20 tendons

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(8). Concrete Structures (Prestressed Concrete Pile)

NIMMO PARKWAY in Virginia

2 Test Piles Nov. 2012
16 Piles Nov. 2013

24” square pile
16 strands: CFCC 1x7 15.2mm
Spiral: CFCC U 5.7mm

FRP for New Construction
(9). **Concrete Structures** (Prestressed Concrete Pile)

**Pilot project**

Jul. 2013 in Florida

- **24” square pile**
- 20 strands: CFCC 1x7 15.2φ
- Spiral: CFCC U 5.0φ
- Pile length:
  - 40 feet × 3 beams
  - 100 feet × 2 beams

*FRP for New Construction*
(10). Concrete Structures (Prestressed Concrete Pile)

Halls River Bridge project 2017 in Florida
FRP for New Construction
Ⅲ. Benefit of CFCC

Bridge Life Cycle Cost

- Black Steel Bridge
- Epoxy-Coated Steel Bridge
- CFRP Bridge

Construction
Deck Shallow Overlay
Deck Replacement
Superstructure replacement

Breakeven year: 20

0 10 20 30 40 50 60 70 80 90 100

Year

$0 $1,000,000 $2,000,000 $3,000,000 $4,000,000 $5,000,000 $6,000,000 $7,000,000

Life-cycle cost

5.98 M$
5.63 M$
2.29 M$

Lawrence Tech

Prof. Grace
Thank you