



Prestressing of Carbon Fiber Elements in Virginia

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E. Alan Saunders, PE, CCM

VDOT Assistant State Construction Engineer

Corrosion Damaged Bridges



One of the leading causes of bridge deterioration is corrosion of the steel.

In 2004, FHWA reported \$10.5 billion in bridge rehabilitation

Improvements at VDOT

Thousands of pounds of stainless CRR for placement in PCUs



PCU Ready for I-95 Deck Replacement

VDOT has improved the corrosion resistance of steel reinforced bridge decks using CRR

Next comes improvements to prestressed elements.

Carbon Fiber Composite Cable (CFCC) or Carbon Fiber Reinforced Polymer (CFRP)

Directionally Strong
Corrosion Free
Lightweight



CFCC Properties

Property	Value
Tensile strength (min)	338 ksi
Elastic Modulus	22,500 ksi
Elongation at break	1.7%
Specific gravity	1.6



CFCC Applications

More than 130 applications by 2009

Prestressed and Post-tensioning

Suspension Bridge Main Cable

Ground Anchor

Stay Cable

Michigan Post Tensioned



Maine Cable Stayed

World's First Bridge Using CFCC

Shinmiya Bridge

Coastal Structure

Replacement built in 1988

Underside now corrosion free

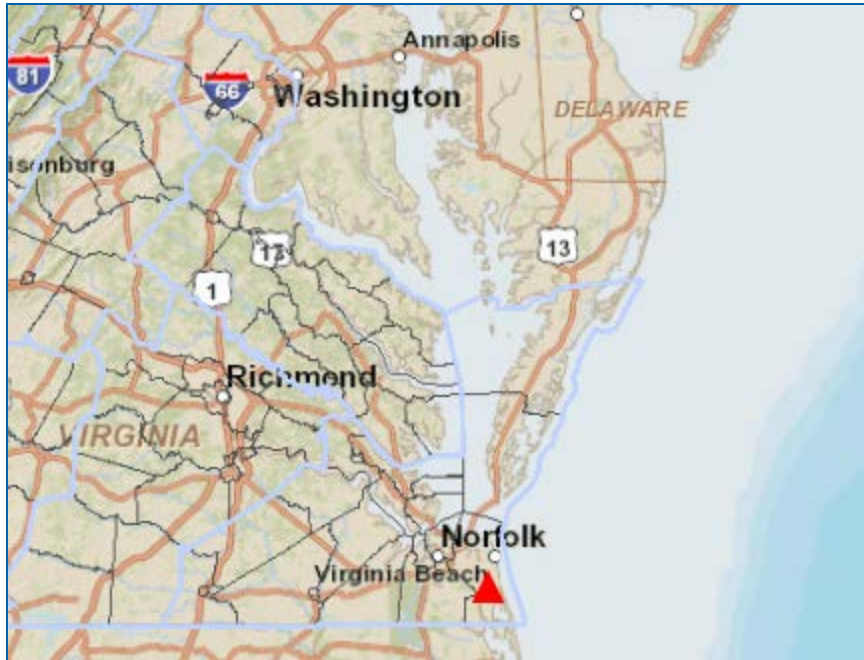


Initial CFCC Pile Research Plan

18 piles would be fabricated using carbon fiber composite cable reinforcement in place of traditional steel strand and spiral
Each pile would have 16 strands 0.6 in diameter CFCC



VDOT's First Application

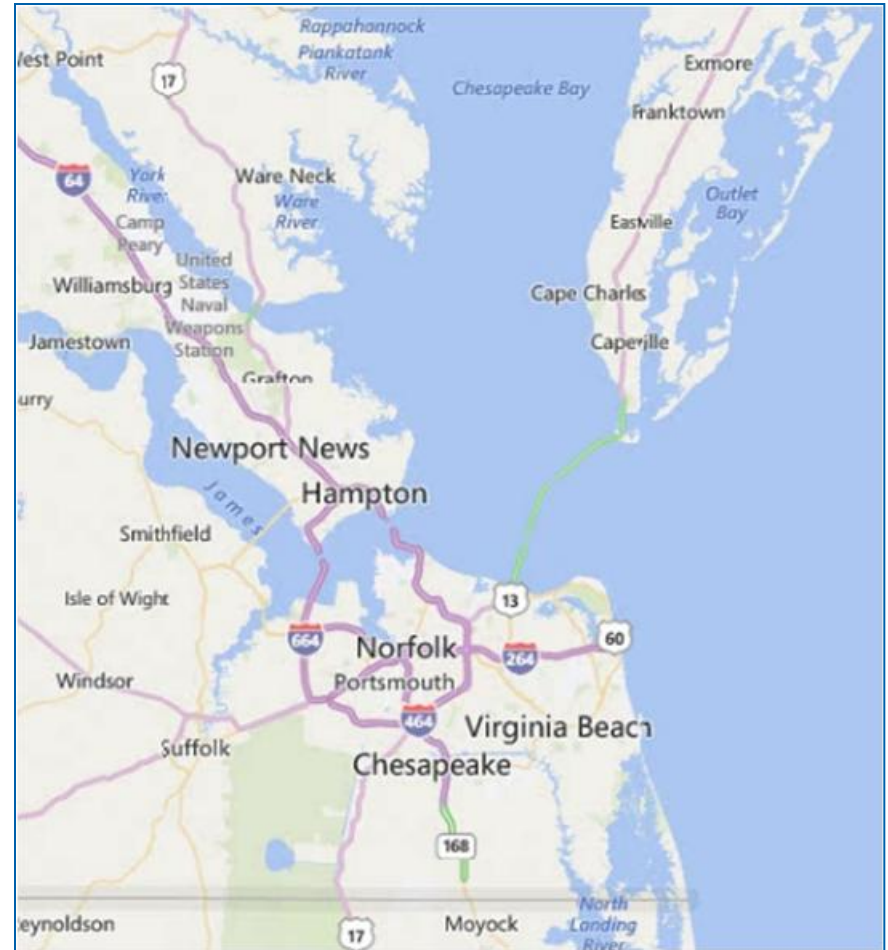


VDOT Nimmo Parkway in Virginia Beach

Pile Fabrication

**Bayshore Concrete
Products fabricated
all the piles**

**Two test piles would be
fabricated at facility
in Cape Charles, VA
Remaining production
piles would be
fabricated at facility
in Chesapeake, VA**



Overview of Casting Areas



180-ft (Cape Charles) and 320-ft (Chesapeake) long beds with steam curing pipes at both plants

The Coupler (AKA. Double Chuck)



**Several parts
required to properly
assemble coupler**



CFCC Details:

No metal or sharp corners

Plastic Tie and Tubes
Circular Spiral



Removable Lift Device



Truly Corrosion Free Piles

Stressing

Stressed

- 5 kips
- 15 kips
- 25 kips
- 34 kips



Concrete Placement and Consolidation



Rubber tipped vibrator ends

CFCC Pile Concrete Placed and Steam Cured



Couplers kept
below 122 F

Pile Removed From Forms



Piles are Transported to Site



Nimmo
Parkway

Preparing Piles for Driving

Piles are lifted and positioned for driving

During Driving

Ram Weight

- 10,141 lbs

Hammer Stroke

- 5.7 – 9.2 ft

Test piles were instrumented



CFCC Reinforced Piles Summary

Success in fabrication and driving

2 test piles fabricated In Nov 2012 and driven in Oct 2013 (11-month cycle)

16 production piles fabricated in Nov 2013 and driven in Dec 2013 (1-month cycle)

Driving response similar to steel reinforced pile

Successful Pile Design

24 inch square pile, with 5.7- mm (0.225-in) CFCC spiral in a circular pattern

16 15.2-mm (0.6-in) strand/pile at 34 kips/strand



CFCC Reinforced Pile Parting Thoughts

Unlike steel strands

Strand cost per foot
higher

Preparing strands for
tensioning is slower

No Buy America
requirement

Corrosion free



Nimmo Parkway

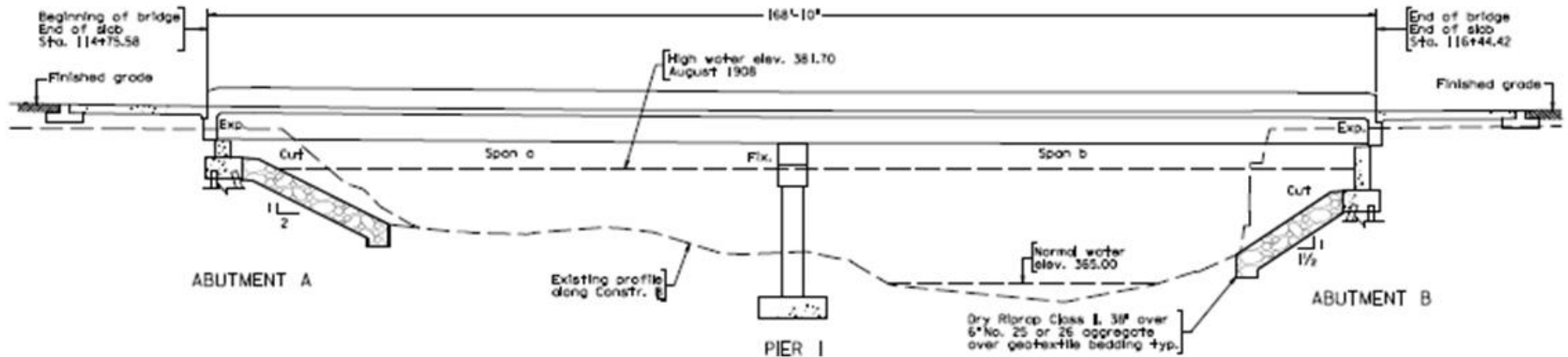
CFCC Beams

Route 49 over Aaron's Creek CFCC Beams

2 span bridge

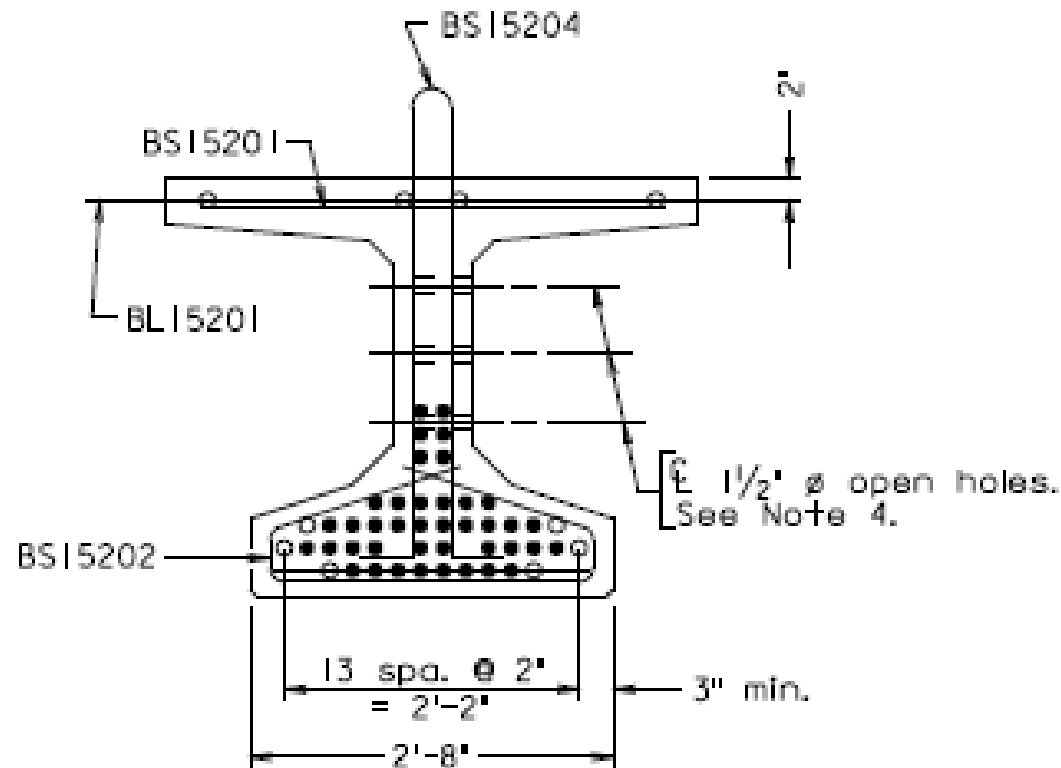
4 beams per span

82-ft length beam



Aaron's Creek CFCC Beams

Each beam
is a 45"
modified
bulb tee
girders



END VIEW

For dimensions not shown, see Typical Beam Section.

● Indicates strand to receive full prestressing

○ Indicates strand to receive 5 kips prestressing

Preparing CFCC Strand



CFCC Tensioned and Beam Forms Closed



Concrete prepared and Tested



Concrete Placed and Finished



Beams are Transported to Site and Erected



CFCC Pile and Beam Summary

Corrosion free piles can be produced and driven using standard practices and equipment

Corrosion free modified bulb tee beams can be produced and erected also using standard practices and equipment

For both CFCC piles and modified bulb tee beams, some design and materials of construction modifications are required

Current Challenges

Industry

- More competitors
- Eliminating delays in bid response
- Minimize shipping issues
- Use of SCC mixes to reduce need for vibrator

Research

- Temperature or coupler slippage concern
- Improvements to end preparation time
- Maximizing material use to reduce cost

DOTs

Define where higher cost AND higher benefit materials could be of value to the DOT and public



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Questions: Celik Ozyildirim (Celik@vdot.virginia.gov)

Stephen Sharp (Stephen.Sharp@vdot.virginia.gov)

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