Virginia Center *for* Transportation
INNOVATION & RESEARCH

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Carbon Fiber Composite Cable in Prestressed Piles and Beams in Virginia

AASHTO Innovation Initiative Meeting
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Carbon Fiber Reinforced Polymer (CFRP) Applications

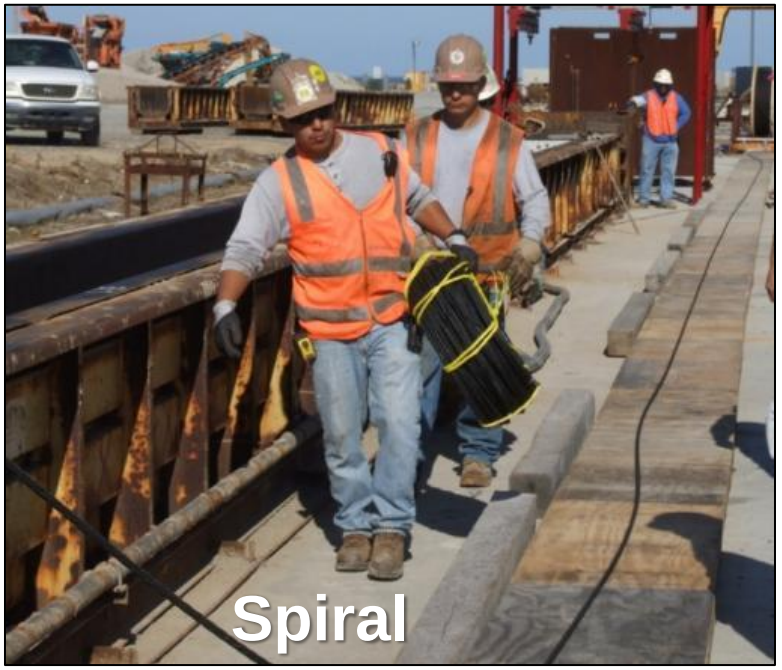
- More than 130 applications by 2009
- Prestressed and Post-tensioning
- Suspension Bridge Main Cable
- Ground Anchor
- Stay Cable

Michigan Post Tensioned

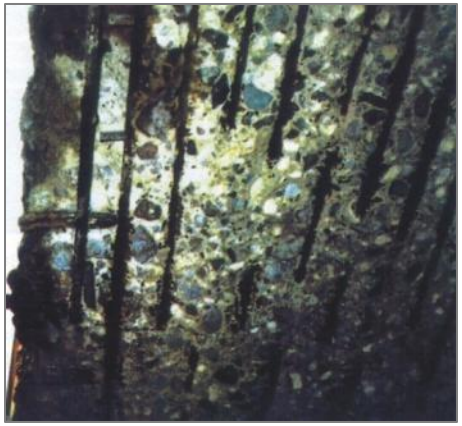
Maine Cable Stayed

CFRP Materials

- Directionally Strong
- Lightweight
- Corrosion Free



World's First Bridge Using CFRP



Initial Bridge
(20 yrs service)

Replacement Bridge
(20 yrs service)

- Shinmiya Bridge
  - Coastal Structure
  - Replacement built in 1988
  - Underside of deck corrosion free

Improvements at VDOT

- **VDOT has improved the corrosion resistance of steel reinforced bridge decks using CRR**
- **Are there other areas of the structure we should look at?**

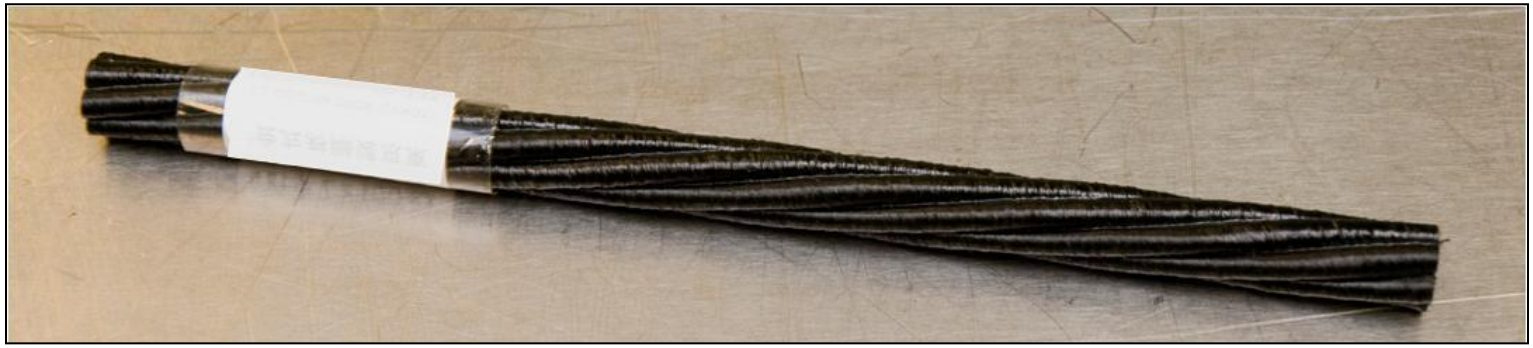
Corrosion Damaged Bridges

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

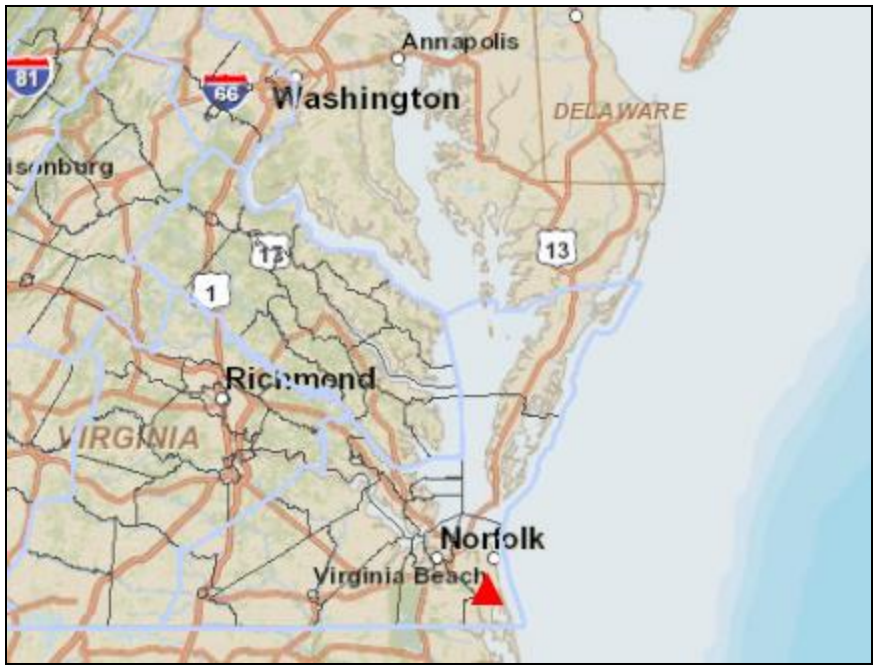
In 2004, FHWA reported $10.5 billion in bridge rehabilitation

Initial Research Plan

- 18 piles would be fabricated using carbon fiber composite cable reinforcement in place of traditional steel strand and spiral
- Each pile would have16 strands 0.6 in diameter CFRP



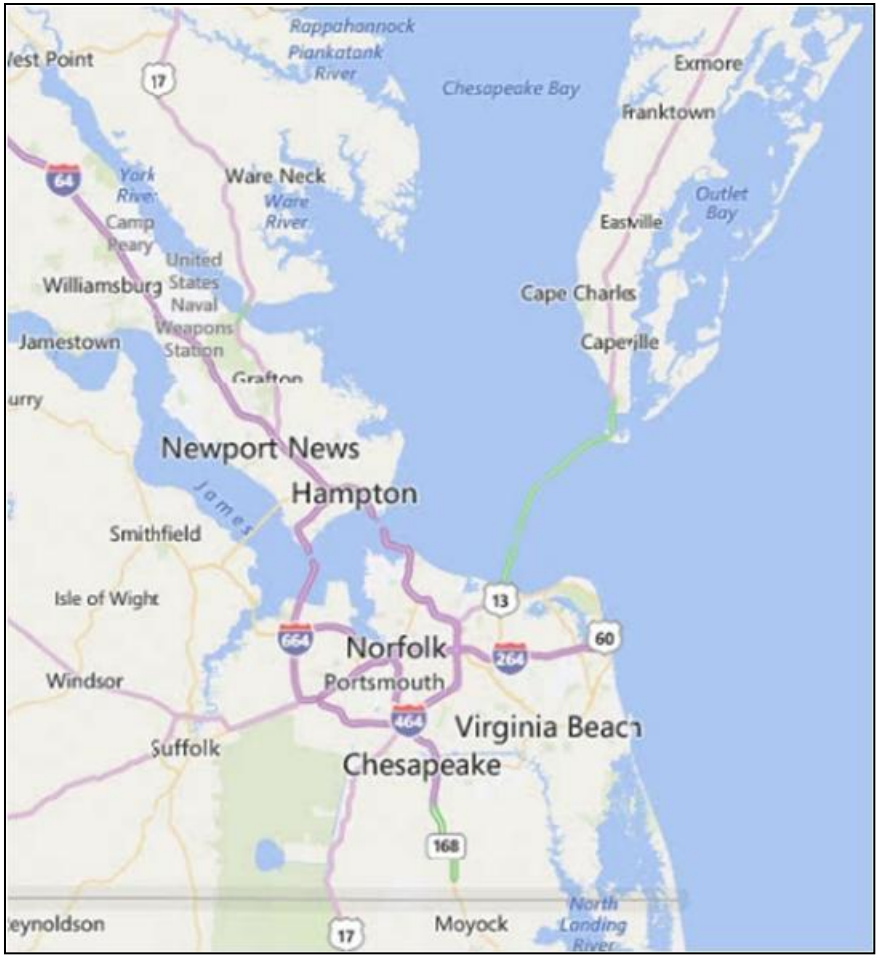
VDOT's First Application



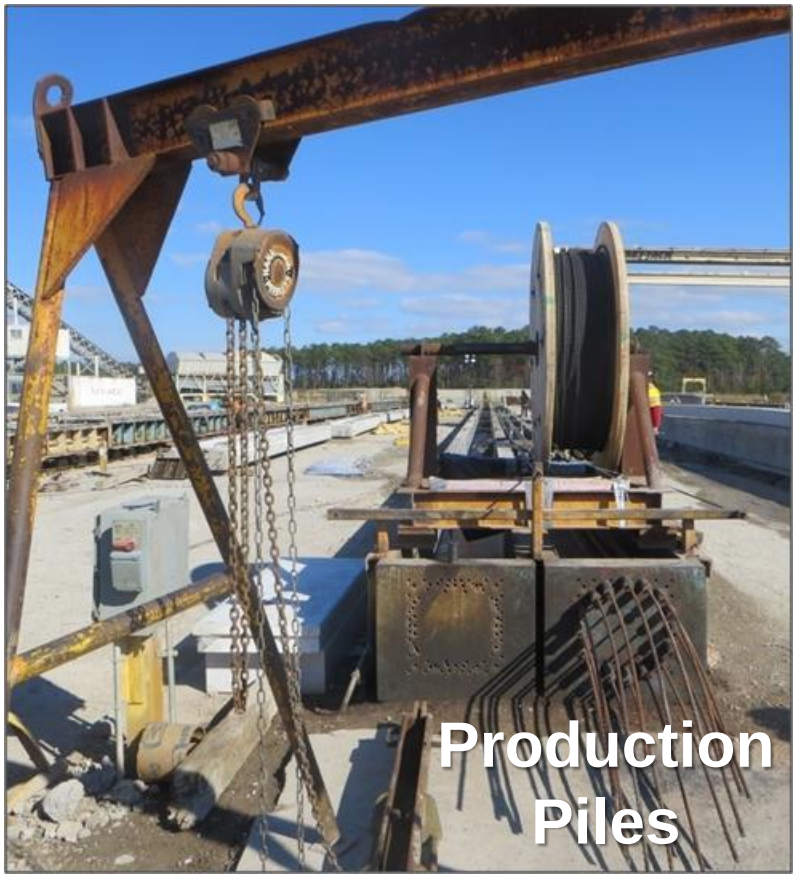
- VDOT Nimmo Parkway in Virginia Beach

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

CFRP Details

- Plastic Tie
- Circular Spiral

- Removable Lift Device

Stressing

Concrete Placement and Consolidation

Rubber tipped vibrator ends

CFRP Pile Concrete Placed and Cured

Steam Curing

Pile Removed From Forms

Piles are Transported to Site

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

CFRP Reinforced Piles Summary

- Success in fabrication and driving
  - 2 test piles fabricated In Nov 2012 and driven in Oct 2013
  - 16 production piles fabricated in Nov 2013 and driven in Dec 2013
  - Driving response similar to steel reinforced pile
- Successful Pile Design
  - 24 inch square pile, with 5.7- mm (0.225-in) CFRP spiral in a circular pattern
  - 16 15.2-mm (0.6-in) strand/pile at 34 kips/strand

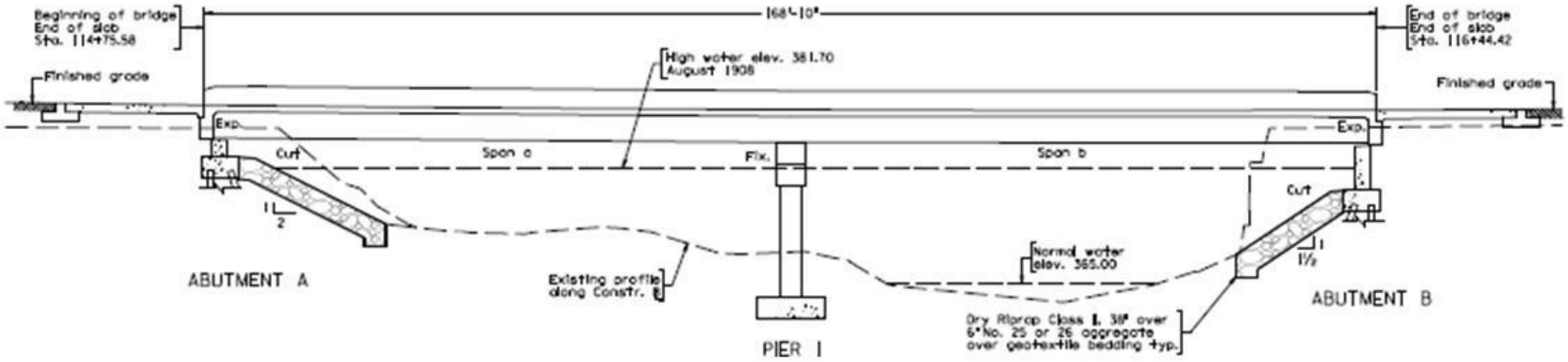
CFRP Reinforced Pile Parting Thoughts

- Unlike steel strands
  - Strand cost per foot higher
  - Preparing strands for tensioning is slower
  - No Buy America requirement
  - Corrosion free

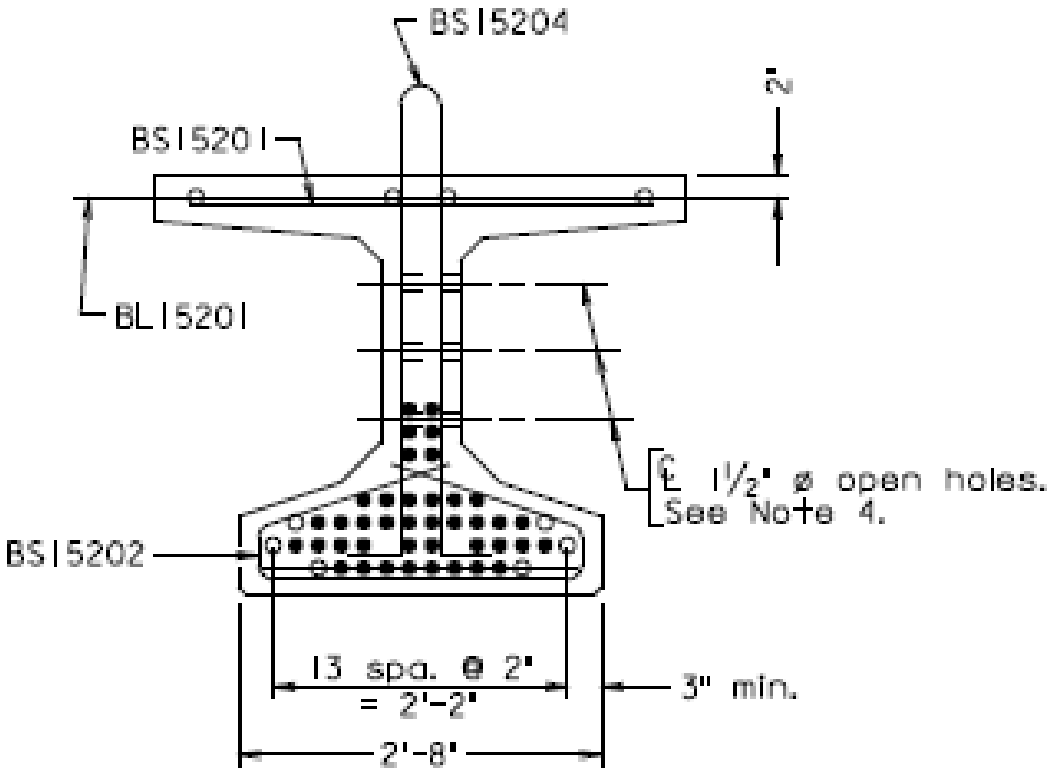
What's Next ?

Route 49 over Aaron's Creek CFRP Beams

- 2 span bridge
- 4 beams per span
- 82-ft length beam



Aaron's Creek CFRP Beams



END VIEW

For dimensions not shown, see Typical Beam Section.

● Indicates strand to receive full prestressing

○ Indicates strand to receive 5 kips prestressing

- Each beam is a 45" modified bulb tee girders

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

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