# A.I.I. | AASHTO Innovation Initiative

# FAST FACTS:

## Carbon Fiber Reinforced Polymer Strands

| | |
|---|---|
| **Project Location:** | Virginia |
| **Agencies:** | Virginia DOT and Virginia Center for Transportation Innovation and Research |
| **URL:** | aii.transportation.org<br>*(*select *Carbon Fiber Reinforced Polymer Strands)* |
| **Project Name:** | VDOT Bridge Piles with Carbon Fiber Reinforced Polymer Strands |
| **Project Description:** | Eighteen pre-stressed concrete piles were fabricated using only carbon fiber reinforced polymer (CFRP) strand reinforcement. The piles were then driven using traditional practices, which provided VDOT with a corrosion-free reinforced concrete pile option to support a bridge along the Nimmo Parkway in Virginia Beach, Virginia. |

**Project Purpose And Need:**

CFRP piles performed comparably to steel in the finished product in terms of material handling, structural erection, constructability, and other factors. Use of the piles, however, will result in lower life cycle costs, including reduced maintenance and rehabilitation work.

This translates to increased worker and motorist safety. It also means that cost savings stay in the roadway user's pocket in the form of less delay (and related fuel consumption) plus reduced vehicle wear and tear.

Like VDOT, agencies from Maine to California are recognizing a host of practical advantages of CFRP.

**Overall Budget/Cost Estimate:**

In early projects, the initial cost of CFRP was higher than that of traditional materials. Much of the increase is attributable to unfamiliarity with this new product. Also, handling and end preparation of the CFRP strands is more labor-intensive, increasing cost.

Overall, however, the cost of CFRP, which, like steel, is only a fraction of the cost of an overall bridge project, is falling as applications, supply and technology advance.

**What was unique about this project?**

This project provided VDOT with a unique pile design that is not only corrosion-resistant, it is corrosion-free.

**Describe Traditional Approach:**

This project was especially important for VDOT because, not only does VDOT use de-icing salts to ensure the safety of the public during winter storms, but VDOT bridges along the eastern portion of the State are often exposed to saltwater. With traditional steel reinforcement, concrete elements will succumb to the constant exposure to saltwater, with corrosion ultimately shortening the structure's service life.

**Describe New Approach:**

A new corrosion-free option is available for pre-stressed piles that requires special handling during production but, once cast, performs similarly to conventional piles.

**Details:**

Traditional steel materials, which mainly follow the ASTM A 416, grade 270 low relaxation strand designation, are uncoated and subject to corrosion, section loss, and eventually loss of pre-stressing force especially due to leaking of chloride solutions at deck joints and exposure to marine environment. This becomes even more of an issue with piles in certain geographic locations since a pile with little vertical clearance can, in effect, be in the splash zone of a saltwater environment resulting in the pile being exposed to salt with daily wetting and drying cycles. This aggressive environment can reduce the service life of steel reinforced elements and result in more frequent maintenance.

During casting, CFRP strands are handled with care and the ends are prepared with protective material to prevent damage since they are brittle, especially in the direction perpendicular to the fibers. During placement and while in service, CFRP cables behave similarly to steel strands at service loads. Concrete handles compression whereas the CFRP strands handle tension in the piles. The main difference between the two options occurs at ultimate load. The CFRP used in the project had higher ultimate strength compared to the steel strands. However, an increased safety factor limits its pre-stressing load to 65% of the ultimate strength at this time.

**Top Innovations Employed:**

- Each pile used 16 CFRP strands, each 0.6-inch in diameter.
- Each pile used a 0.225-inch CFRP spiral in a circular pattern.
- The piles were released from the forms using removable metal lift devices so that contact with a metal is not permitted.
- Embedded plastic grout tubes were used to isolate the CFRP strands from the steel in the pile cap.

**Primary Benefits Realized To Date:**

Due to the limited exposure to date of this structure, the primary benefit of longevity has not yet been realized. However, experience from earlier structures with CFRP indicate that it:

- Eliminates the need for grouting for corrosion protection in post-tensioning applications.
- Provides more tendon replacement options.
- Creates more options for repairs from high load hits.

**Other Benefits Realized/ Expected:**

- Since fabricators of CFRP strands can vary the cross-sectional diameter, some applications that have required multiple single strands of conventional steel to reach the required load can be redesigned to require only a single, slightly larger diameter CFRP strand, resulting in a more efficient use of the strand material.
- It is expected that, due to the high strength capacity of the CFRP equivalent cross sections compared to conventional steel, CFRP can be used even though the pre-stressing load at this time is limited to 65% of the ultimate strength. This should result in additional cost savings due to the use of less CFRP material.

**Project Start Date/ Substantial Completion Date:**

**VDOT Contract Execution Date**
December 2011

**VDOT Project Acceptance Date**
December 2014

**Affiliations:**

Tokyo Rope/Tokyo Rope USA (CFRP manufacturer)

Bayshore Concrete Products Corporation

Dr. Nabil Grace, Lawrence Technological University

**Project Contacts:**

Mark Chaput, A.I.I. Team Chair, MDOT
chaputm@michigan.gov

Matthew Chynoweth, MDOT
chynowethm@michigan.gov

Stephen Sharp, VDOT
stephen.sharp@vdot.virginia.gov

Omar Abu-Hajar, ODOT
omar.abu-hajar@dot.ohio.gov

Jim Gutierrez, Caltrans
jim.gutierrez@dot.ca.gov

Wayne Frankhauser, Jr., MaineDOT
wayne.frankhauser.jr@maine.gov

Dr. Nabil Grace, Lawrence Technological University
ngrace@ltu.edu

CFRP piles being steam-cured after stressing of the strands and concrete placement. A spool of CFRP strand can be seen above the stressing bed.

Pre-stressed pile with corrosion-free CFRP reinforcement being driven at the Nimmo Parkway Bridge site in Virginia Beach, Virginia.

CFRP piles being removed from the forms and inspected.

Corrosion-free CFRP piles adjacent to West Neck Creek after restrike and redrive, with a final elevation of 61'.

AASHTO Innovation Initiative

**Visit**

**aii.transportation.org**

**and click on**

**CARBON FIBER REINFORCED POLYMER STRANDS**

Prepared September 15, 2015