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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
*(*select *Carbon Fiber Reinforced Polymer Strands)*

Project Name: VDOT Bridge Beams with Carbon Fiber Reinforced Polymer Strands

Project Description: Eight pre-stressed concrete beams were fabricated using only carbon fiber reinforced polymer (CFRP) strand reinforcement. These were placed using traditional practices, which provided VDOT with a corrosion-free, reinforced concrete beam option supporting a bridge deck in Halifax County, Virginia.

Project Purpose And Need:

VDOT chose CFRP because it performs comparably to steel in the finished product in terms of material handling, structural erection, constructability, and other factors. But it promises 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 unique bulb-tee beams that are not only corrosion-resistant, they are 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 beams that requires special handling during production but, once cast, performs similarly to conventional beams.

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 beams in certain geographic locations since a beam with little vertical clearance can, in effect, be in the splash zone of a saltwater environment resulting in the beam 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 beam 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 beams. 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 stress to 65% of the ultimate strength at this time, making it respond similarly in load carrying capacity to conventional steel reinforcement.

Top Innovations Employed:

- Each beam was a 45" tall pre-stressed bulb-tee beam completely reinforced with CFRP, including CFRP strands and stirrups.
- Each beam used 48 CFRP strands, each 0.6-inch in diameter.
- The beams were released from the forms using removable metal lift devices so that contact with a metal was not permitted.
- Embedded plastic ties were used to ensure CFRP strands and stirrups remained securely in place during concrete placement.

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
November 2014

VDOT Estimated Completion Date
June 2016

Affiliations:

Tokyo Rope/Tokyo Rope USA (CFRP manufacturer)

Coastal Precast Systems

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Placement of concrete during fabrication of CFRP beam.

Placement of corrosion-free CFRP beam at jobsite.

Deck work at jobsite with all eight CFRP beams in place.

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