Florida Department of Transportation Research

Investigation of Carbon Fiber Composite Cable in Prestressed Concrete Piles
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FDOT commonly uses concrete piles prestressed with steel strands in bridge foundations due to their economy of design, fabrication, and installation. However, when installed in marine environments, the steel strands are prone to corrosion and degradation, resulting in costly repairs or replacement.

Researchers at Florida State University recently studied the suitability of replacing steel prestressed strands with carbon fiber composite cables (CFCC), an advanced material that does not corrode. One objective was to demonstrate that it is possible to grip and stress the carbon strands. Other objectives were to determine the transfer and development length of CFCC strands and investigate the flexural capacity and drivability of CFCC prestressed piles.

Left: a pile being constructed using steel prestressing strands. Right: a pile being constructed using CFCC prestressing strands.

Researchers cast five 24-inch-square prestressed concrete piles—three 40-feet long and two 100-feet long—using 0.6-inch diameter CFCC strands. Researchers used a special anchoring system and documented the techniques employed to prestress the strands, as well as the unique aspects involved in constructing and precasting CFCC-prestressed piles. During strand detensioning, stresses were monitored in the concrete at the piles' ends to determine the transfer length of CFCC strands as a means of evaluating their bond characteristics.

Researchers next performed development length and flexural tests on two of the 40-foot-long piles to further assess the performance of the CFCC strands. Finally, the two 100-foot-long piles were driven at a bridge construction site adjacent to standard steel-prestressed concrete piles. During driving operations, researchers monitored the behavior of the piles using embedded data collectors and Pile Driving Analyzer®.

Tests performed during detensioning when the piles were constructed showed that the transfer length of the CFCC strands was more than 30% shorter than predicted by equations for steel prestressing strands. This means that the CFCC strand's initial prestressing force can be transferred to the concrete pile in a shorter length than steel strands. Researchers also found that development length was less than 72 inches, which is also less than design code predictions. In addition, the flexural strength of the CFCC-prestressed concrete pile was 8% higher than predicted, providing further evidence of the suitability of this type of pile construction. The piles performed well with no major damage or loss of prestress when they were subjected to hard driving conditions and high internal compressive and tensile stresses.

This study demonstrated that the performance of piles prestressed with CFCC strands is comparable to those prestressed with steel. Researchers concluded that CFCC-prestressed concrete piles can be a good alternative to conventional concrete piles with steel prestressing, particularly for bridge foundations in corrosive environments. Although constructing prestressed concrete piles with CFCC strands instead of steel initially costs more, the use of CFCC can result in bridges that require less maintenance and last much longer, thus reducing the long-term cost of bridges.

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