Florida Department of Transportation Research

Waterline Pile Cap Footings for Bridges using Large Diameter FRP Reinforcing – Material Characterization and Design

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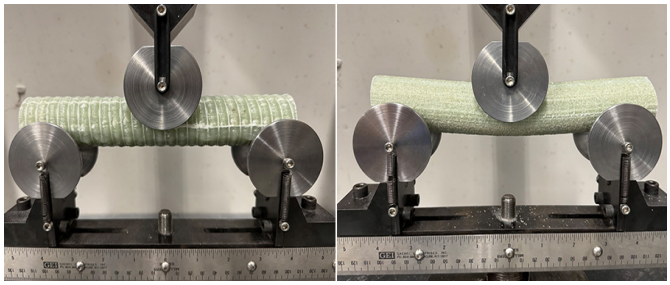
Project Manager
Steven Nolan, P.E.
Structures Design Office

Principal Investigator
Antonio Nanni, Ph. D., P.E.
University of Miami

Background

In Florida's coastal areas, the tidal zone causes corrosion of steel reinforcement in bridge waterline pile cap footings, which support elements like piers and columns. This corrosion leads to costly and time consuming repairs. One potential solution is to use corrosion resistant fiber reinforced polymer (FRP) reinforcing bars instead of steel. However, although Florida bridges typically use steel bars up to size No. 11 (1.375 in), no standards currently exist for No. 11 FRP bars. While the AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Guide Specifications for Glass Fiber Reinforced Polymer (GFRP) Reinforced Concrete allow designing pile cap footings with GFRP bars, it has not yet been demonstrated how larger FRP bars perform in these critical structural elements. Without design guidance and material acceptance criteria for larger FRP bars, engineers cannot confidently adopt this potentially beneficial alternative, delaying service life improvements and long-term cost savings for coastal bridges.



Horizontal shear test of No. 11 GFRP Bars from two different manufacturers.

Research Objectives

The objective of the research was to identify what further research is needed to use larger FRP bars in waterline pile cap footings, develop material acceptance criteria and design specifications for No. 11 glass FRP bars, and create design examples to help implement these bars in practice. Additionally, the study provided recommendations for future research to support broader use of larger FRP bars in other structural components, considering the known limitations of GFRP compared to steel.

Project Activities

The University of Miami research team reviewed applicable design specifications and existing guidance related to GFRP reinforcement and evaluated the feasibility of using current maximum bar sizes in pile caps. Work focused on developing material acceptance and design specifications specifically for No. 11 glass FRP bars, which do not yet have established standards. As part of this effort, the team prepared practical design examples showing how the new criteria and specifications could be used in real waterline pile cap footing designs. Finally, the study outlined future research needs needed to expand FRP bar use to other bridge components.

Project Conclusions and Benefits

The project produced material acceptance criteria and clear design specifications for No. 11 glass FRP reinforcing bars in waterline pile cap footings, addressing a key gap in current practice. The design examples help bridge engineers and designers understand how to apply these new criteria in real project situations.

By enabling the use of larger corrosion-resistant FRP bars, this work supports improved durability and longer service life for coastal bridge foundations, potentially reducing future maintenance costs and providing economic value over the long term. Additionally, the recommendations for future research provide a roadmap for expanding FRP use beyond pile caps to other structural elements, further enhancing the long-term durability of Florida's bridges.

For more information, please see fdot.gov/research.