Florida Department of Transportation Research

Development of FDOT SERF and RETA Design Equations for Coastal Scour When a Single Vertical Pile Is Subjected to Wave Attack

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Current Situation

Scour occurs where flowing water encounters resistance, as at a bridge pile, and some of the flow is directed downward and digs out the ground at the base of the pile, reducing its bearing capacity. Scour causes more than half of U.S. bridge failures, making it a major concern for bridge designers. Scour is a very complicated problem in physics, and historically, design guidelines for scour were based on simplifying assumptions, for example, that all bed materials erode at the same rate. In the early 2000s, research funded by the Florida Department of Transportation (FDOT) resulted in improved methods that more accurately predicted scour by relating it to standardized tests, namely, the Sediment Erosion Rate Flume (SERF) and Rotating Erosion Testing Apparatus (RETA). However, while the new methods were accurate for sandy materials, they overestimated scour for highly cohesive materials like rock. Also, the methods are based on steady river-like flows and are not sufficiently accurate for coastal environments where wave and tidal action cause flows to vary continuously in force and direction throughout the day.

Research Objectives

University of North Florida researchers used advanced modeling techniques to simulate scour of piles due to wave action. Their goal was to extend existing FDOT design methods to coastal scour conditions.

The piers of the Seven-Mile Bridge in the Florida Keys are constantly subjected to waves and currents.

Project Activities

Fluid dynamics is a branch of physics that describes the forces in moving liquids, often requiring calculations that can only be performed by computers, referred to as computational fluid dynamics (CFD). In this project, the researchers developed equations that describe the effect of wave action on single piles and applied them to a variety of computer-simulated piles.

First, the researchers tested their CFD method on small-scale digital mockups of bridge piles. They accurately reproduced previously reported experimental data. The method was then applied to large-scale digital mockups of various pile configurations. Maps of maximum near-pile stress, the force that leads to scour, were created for each mockup.

Finally, the researchers developed a relatively simple parametric model to predict maximum near-pile stress that is a function of wave parameters and structural geometry and relates stress to the RETA and SERF tests. The parametric model reproduced the stress data with accuracy at intermediate values, but less so at lower and higher stresses. The sources of the problems at higher and lower stresses were investigated, and a more sophisticated model was developed. The new model reproduced the stress data almost perfectly.

The revised parametric model is a useful design tool for single piles under coastal scour conditions. Future work could be conducted to expand the model to accurately map stresses for more complex bridge support structures such as pile caps or clustered piles.

Project Benefits

Improved methods can lead to better-designed coastal bridges that serve their design life with less repair and maintenance.

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