Florida Department of Transportation Research

Effects of Downdrag on Pile Performance

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Current Situation

Driven piles are a common deep foundation type used to support bridges. The most common construction sequence for end bents, supporting structures at the very end of a bridge's span, is to drive end bent piles and progressively build mechanically stabilized earth (MSE) walls around the end bent piles while simultaneously adding fill soil behind the wall and around the piles. The addition of the fill soil causes settlement of the existing soil which, in turn, grabs hold of the piles and pulls them downward. The forces in the piles caused by the embankment settlement are called "drag forces," per new AASHTO terminology. The process of pulling the piles down from drag forces is referred to as "downdrag."

A 70-kip loaded truck is parked over a pile in end bent at the Sandridge Road testing site.

Research Objectives

The objectives of this research were to determine the magnitude of downdrag forces within granular soils and to investigate the behavior of the drag forces, foundation, and superstructure over time. In addition, the project aimed to develop a rational approach to the computation of the forces to provide a template that could be adopted in the Soils and Foundations Handbook.

Project Activities

Following a literature review, the University of South Florida research team selected three bridge sites across two FDOT districts to monitor the progression of construction-induced loads with a focus on the downdrag forces on the piles.

To do this, the team identified two computational methods to estimate embankment settlement and then used boring—the process of drilling into the earth to collect soil and rock samples—to evaluate the soils around each of the bridge sites. Next, the team tied new vibrating wire technology from the rebar cages of the end bents of the piles to measure both short-term and long-term settlement and strain. The same wires were also routed to an external data collection system that would be mounted for the duration of the construction of the bridges.

The research team analyzed the data collected from the external device.

Project Conclusions and Benefits

The research shows that downdrag from compressible sandy soil layers contributes significant permanent loads to the pile and therefore should be evaluated for all piles where embankments are constructed after pile installation. This new information will allow FDOT to more accurately account for these drag forces.