Florida Department of Transportation Research

Quantifying Pile Rebound with Deflection Measuring Systems Best Suited for Florida Soils

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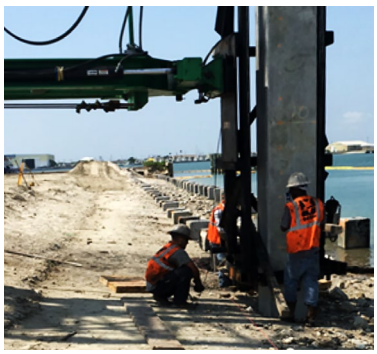
Current Situation

Florida soils consist of various sand, silt, and clay blends. Building on these soils often involves driving piles well past 50 feet to support the weight of structures. Blends of very fine sands with silts and clays produce difficult pile driving conditions, during which piles bounce or rebound upward after each hammer strike. These problematic blends are termed high rebound soils. Rebound can significantly complicate pile driving by increasing the number of blows necessary to drive the pile to the desired depth, plus more hammer blows increase the risk of serious pile damage. Engineers also rely on blow counts to verify the piles' bearing capacity; therefore, excessive rebound can make these critical calculations less certain. Rebound becomes problematic, especially for large concrete piles, where considering the size of structures, a fraction of an inch can be important but difficult to measure.



Workers inspect a driven concrete pile.

Research Objectives

Florida Institute of Technology (FIT) researchers evaluated two new pile movement technologies: a commercially available pile driving monitoring (PDM) system and FIT's camera monitoring system (CMS). These systems were used in conjunction with traditional pile driving measurement equipment to validate measurements in Florida's high rebound soils.

Project Activities

The researchers monitored pile driving and standard penetration tests (SPTs),at six Florida sites, using both CMS and PDM equipment. When PDM and CMS measurements of pile movements were compared to deflections found using traditional pile driving analyzer (PDA) gauges, these new devices produced excellent results, yielding deflections within 1 mm of each other.

In an effort to examine how SPT rods moved through high rebound soils, both CMS and PDM measurements revealed a damping, or time-dependent movement, also known as creep (i.e., the longer a load is applied, the more the soil compresses). Creep, like rebound, affects capacity calculations, making it difficult to verify the exact load a pile can be expected to carry.

Using 42 sets of existing cyclic soil test data from six Florida sites, which included 25 million data points, a damping coefficient sensitivity analysis of high rebound soils was completed. Typical unitless damping coefficients used in pile analyses are near 0.25. Two analytical approaches were used on these data: one based on the cyclic movements associated with stress and time and a second based on the viscous energy absorbed per cycle. Stress-time damping coefficients mostly ranged from 0.01 and 1.0 s·lb/in^2, while the average viscous energy dimensionless coefficients per site ranged from 0.25 to 0.31. Viscous results more closely matched published values from the standard Case Western Reserve Institute study and proved to be a better method for interpreting cyclic soil data for analyzing pile driving. The damping coefficients were also evaluated using the Case analysis CAPWAP method. The researchers found that both the pile shaft and toe resistances significantly affect rebound.

Project Benefits

These improved means of characterizing Florida soils and measuring pile movements during construction will help ensure that driven pile foundations will efficiently perform as designed.

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