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Times are Fast... and so is Pile Testing

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Dynamic pile testing has become routine in modern foundation engineering practice around the world. The Florida Department of Transportation (FDOT) employs dynamic pile testing and analyses methods (PDA, CAPWAP, GRLWEAP) virtually on all their bridge projects. Testing is performed by in-house FDOT engineers or by specialty consultants under contract. Testing is often performed on a selected number of test piles in a testing program ahead of actual construction to verify geotechnical design assumptions and assess pile driveability. In addition, during the production pile driving phase, questionable piles are proof tested as a check on the adequacy of their bearing capacity and/or structural integrity.

Significant savings in cost and construction time are the main advantage of dynamic pile testing over other pile quality assurance methods. However, the effectiveness of dynamic pile testing depends to a large degree on the timely submittal of testing results to decision makers. In fact, to avoid installation problems, driving stresses and structural integrity information from the PDA must be interpreted in real time during pile driving and testing for immediate adjustments of the driving system, if necessary.

For a typical FDOT piling project, the following steps must be taken:

- Evaluation of the contractor's Pile Installation Plan, including preliminary GRLWEAP driveability analyses
- PDA dynamic pile testing of designated test piles
- CAPWAP analyses with representative data
- Refined GRLWEAP analyses based on specific site/hammer/pile conditions
- Formulation of engineering recommendations for production pile lengths and driving criteria

The following case history of a project in the FDOT District 5, demonstrates the effective use of dynamic testing. The $5.23 million, 680 m long bridge for State Road 600 over Reedy Creek in Osceola County consists of thirty spans. For each of the 2 end bents and 29 intermediate bents, the design called for rows of 5 to 7 closed ended steel pipe piles of 610 mm outside diameter and 13 mm wall thickness. The piles were delivered to site in 20 m long sections. Required ultimate static pile capacities ranged between 1700 and 2400 kN. Soils consisted of a 4 m thick peat layer over mixed layers of sandy silt and clayey sand to depths varying from 20 to 80 m below existing ground. The bearing layer was limestone with N-values varying between 50 and refusal.

A special feature of this design-build project was the innovative construction method. For a variety of environmental, geotechnical, and other reasons, the contractor elected to employ a "top-down" method of construction. The process consisted of placing the main construction crane on an independently supported platform ahead of the constructed part of the bridge. Starting at one end of the project, the crane is used to drive the piles for two bents, place the prefabricated pile cap-beam, lay the bridge structural beams, and pour the concrete slab before moving ahead. For the substructure work, a total of twenty-two test piles with lengths between 23 and 85 m were tentatively specified in the project documents. Two different diesel hammers, ICE 80S and 120S, were used throughout the job.

The first pile in a bent was tested with the PDA during initial driving and after 30 minutes for a set-check. Driving of the test pile was finished after either reaching 3 m of penetration with required ultimate PDA capacity, or a refusal blow count.

Site view of Bridge over Reedy Creek

The contractor then continued by placing the starter sections of the remaining piles in the bent. Meanwhile, GRL's engineer plotted and analyzed PDA data using CAPWAP and established a production pile length recommendation. Based on the CAPWAP results, refined GRLWEAP wave equation analyses were then performed as a basis for the pile driving criteria. Typically, the entire pile driving, testing, data analysis, and engineering recommendations process including review by the FDOT required less than 24 hours. Production pile length and driving criteria contained in a signed and sealed report were delivered to the site when the contractor was just about done with vibrating the starter sections of the production piles and welding the add-on sections ready for driving.

This is a perfect example of using dynamic testing in the pile design and construction process to save time and money. This project required pile driving data analysis and foundation engineering be completed with minimal delay. Prompt action by GRL and FDOT engineers was necessary for the "top-down" method of construction on this project to be cost effective.