GRL Engineers, Inc.

Mukilteo Multimodal Ferry Terminal Replacement Project

Challenge:

This project in Mukilteo required testing of drilled shafts and driven piles for the ferry terminal foundation. GRL Engineers provided pile driving monitoring of steel pipe piles and crosshole sonic logging of three structural drilled shafts. The previous terminal had been used for over 60 years. The state worked directly with eleven federally recognized tribes to create a space that celebrated the history of the land, while offering an environmentally friendly space. This team implemented special precautions to keep the surrounding land and sea unharmed, as to not disrupt the ecosystems, and to minimize the terminal's carbon footprint.

The project also included utilizing a working "bubble curtain" to surround each pile with bubbles for both plumb and battered pile conditions, and with varying depths of water and pile penetration. The bubble curtain was used to protect nearby fish from the noise of the hammer impacts. In addition, the CSL access tubes were located in a confined space, which required air quality testing to provide a safe working environment for the contractors and engineers.

Project Details

Client: Manson Construction Company

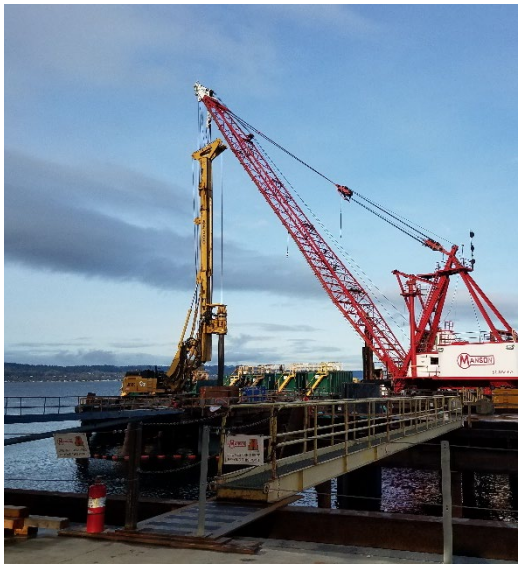
Location: Mukilteo, Washington

GRL Office: Washington

GRL Services

- Crosshole Sonic Method (CSL)
- Pile Driving Monitoring
- GRLWEAP Wave Equation Analysis

Method:



GRL Engineers performed CSL testing on one 10.5' diameter shaft and two 6.7' diameter shafts. With confined working space, performing the test proved to be a challenge. The CSL testing was pertinent, as the three drilled shafts were for the structural operation of the terminal, which would be used for loading and unloading the ferries. Being that the drilled shafts were a main structural component, the designer of the terminal requested a quality assessment of the shaft construction and concrete. The CSL test was composed of probes that were lowered into the steel access tubes running the length of each shaft. The probes were pulled simultaneously for each combination of tubes, and collected data via ultrasonic signals. The lengths of the shafts tested ranged from approximately 73 to123 feet.

For the fishing pier, pile driving monitoring was necessary to install the steel pipe piles. The GRL Engineer used a Pile Driving Analyzer® (PDA) to monitor each hammer blow, for the selected test piles. With the "bubble curtain" and importance of the site to the indigenous people, great care and caution was taken during this process. Before the driving had begun, a GRLWEAP wave equation analysis was performed. The assessment considered the adequacy of the impact driving hammer, and estimated pile driving stresses, hammer stroke height, and blow count to be used during driving. Having this information prior to driving prepared the construction team for the most efficient process.

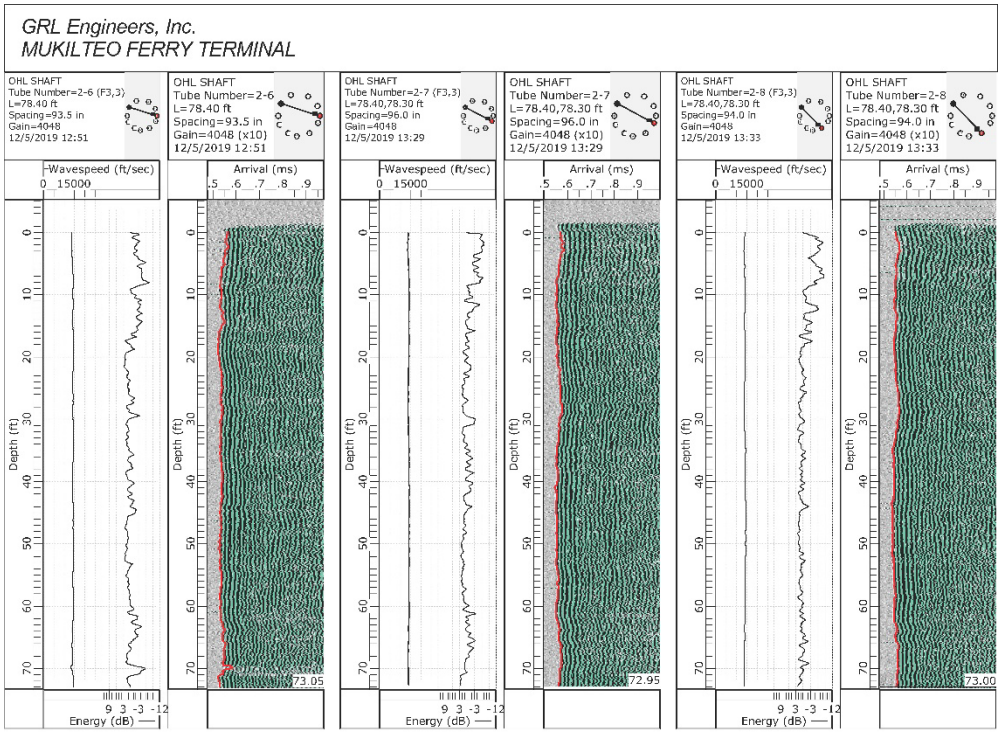
Results:

Sample data collected from the CSL tests can be seen in Figure 1. GRL Engineers assesses and reports the relative concrete and shaft construction quality based on the signal first arrival times and signal strength. The signal wave speed is also calculated based on the distance between the tubes at the shaft top.

As is common for this test, some anomalies may be detected, quantified, and described by location in the shaft. In this way, GRL Engineers assists the Engineer of Record and the Design Team, who will ultimately determine any potential effects on foundation performance and decide on shaft acceptability, or whether any remediation is necessary. All three shafts for this project were deemed acceptable following the testing and analysis.

The monitoring of the 24-inch diameter steel pipe piles with the Pileco D62-22 hammer was similarly successful. Monitoring two piles during restrike, and subsequent CAPWAP analysis verified that the required pile resistances were achieved. Of particular interest for this project was the uplift capacity, which was estimated to be 206 and 168 kips ultimate for piles with 50 and 39 feet penetration below mudline, respectively; the maximum required uplift ultimate capacity was 90 kips. Figure 2 displays sample PDA data.

To learn more about GRL Engineers, visit www.grlengineers.com or email us at info@grlengineers.com.



Pile Dynamics, Inc. Cross-Hole Analyzer

Figure 1: Sample CSL test results

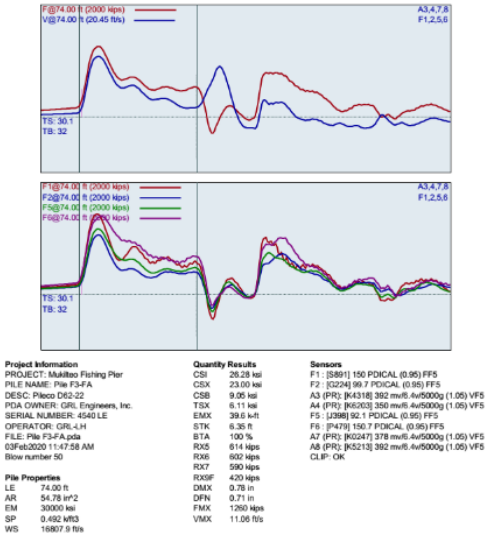


Figure 2: Sample PDA test results