GRL Engineers, Inc.

I-77 Canton Bridge Structures

Challenge:

A large aquifer in Canton, OH caused difficulties in foundation installation for new ramp and mainline bridge structures on I-77. The design called for drilled shafts to be installed, but an early demonstration shaft indicated the aquifer created conditions that prevented the use of drilled shafts at one pier location, as the design called for the shafts to penetrate the aquifer. The awarded contractor, The Beaver Excavating Company, evaluated the situation and made the necessary changes to the installation plan. Initially, GRL Engineers were contracted to evaluate the shaft bearing soil using the Shaft Quantitative Inspection Device (SQUID), evaluate shaft integrity using Thermal Integrity Profiling (TIP), and perform Dynamic Load Testing using an APPLE drop hammer to evaluate shaft capacity.

Due to the difficulties of installing deep drilled shafts, ODOT broached uncharted territory and the design for the pier in question was changed to continuous flight auger (CFA) piles. Static Load Testing, Dynamic Load Testing with CAPWAP® Data Analyses, and TIP were implemented on the CFA piles.

Method:

In phase 1, the bearing soil was evaluated using the SQUID prior to concrete placement. The contractor handled the equipment onsite and GRL collected the data remotely from the office. Shaft integrity was evaluated using TIP, and the contractor installed the Thermal Wire® cables, along with TAG and TAP-Edge data collectors. The thermal data was uploaded automatically to a secure cloud server and analyzed without the need for a GRL engineer to visit the jobsite.

Dynamic Load Testing was performed on 3 shafts using an APPLE drop weight system (**Figure 1**). The shafts were impacted with a load testing device utilizing a 32-kip ram weight and variable drop height. Drop heights used during testing ranged from 1.0 foot to 5.5 feet. Each dynamic load test was completed in a single day and allowed the designers and owner to confirm the shaft design and load carrying ability.

In phases 3 and 4, GRL's APPLE 4, utilizing an 8-kip ram weight, was used to perform Dynamic Load Testing on the CFA piles (**Figure 2**). The CFA piles had lengths around 54 feet below the top of the template, and the piles were extended 1.5 feet above the template to facilitate testing. Following Dynamic Load Testing, CAPWAP analysis was utilized to simulate a Static Load vs. Settlement curve. Finally, a static load test was performed on a CFA pile.

Results:

In phase 1, the SQUID test results indicated variable conditions at the shaft toe, some areas where the shafts terminated above the aquifer indicated relatively dense soils (**Figure 3**), while other locations, apparently within the aquifer, indicated almost no strength (**Figure 4**), as if the soil was suspended. TIP results illustrated the contractor had installed quality shafts (**Figures 5 & 6**). Dynamic Load Testing using the APPLE drop weight system allowed for multiple load tests to be conducted

Project Details

Client: The Beaver Excavating Company

Owner: Ohio Department of Transportation

Location: Canton, Ohio

GRL Office: Ohio

GRL Services

- Shaft Quantitative Inspection Device (SQUID)
- Thermal Integrity Profiliing (TIP)
- Dynamic Load Testing with APPLE
- CAPWAP® Data Analysis
- Static Load Testing (SLT)

quickly and at a fraction of the cost of performing large Static Load Tests. Data acquired from the dynamic tests were then analyzed in the CAPWAP software program to further evaluate static capacity including the soil resistance distribution along the shaft and at the toe.

Phases 3 and 4 of construction included the first CFA piles used to support a bridge structure in ODOT history. GRL Engineers performed the first Dynamic Load Tests on CFA piles for ODOT (**Figure 7**). Static Load Tests and CAPWAP Analysis were implemented to compare data from the Dynamic and Static Load Tests. The maximum mobilized capacities for the tested piles were well above the required nominal pile resistance (**Figure 8**).

During Static Load Testing, the pile did not experience plunging failure, but the results were very comparable to the dynamic testing results. Ultimately, ODOT found the results from the Dynamic Load Test to be satisfactory and created a new supplemental specification for CFA piles. To learn more about GRL Engineers, visit www.grlengineers.com or email us at info@grlengineers.com.

Project: ODOT 328(18) Bridge STA-30-1487 Ramp D Forward Abutment — Hammer: 32-kip Drop Hammer

Shaft Number	Analysis Impact Number	Observed Set (in)	Test Date	Mobilized Capacity Total (kips)	Mobilized Capacity Shaft (kips)	Mobilized Capacity Toe (kips)	Soil Damping Shaft (sec/ft)	Soil Damping Toe (sec/ft)	Soil Quake Shaft (in)	Soil Quake Toe (in)
12	1	0.06	3/13/2020	**580**	410	170	0.61	0.61	0.03	0.06
	2	0.08	3/13/2020	**780**	590	190	0.38	0.22	0.04	0.16
	3	0.09	3/13/2020	**910**	695	215	0.40	0.27	0.04	0.18
	4	0.10	3/13/2020	**1040**	825	215	0.40	0.33	0.04	0.21
	5	0.15	3/27/2020	**1180**	889	291	0.42	0.40	0.04	0.20
	6	0.20	3/27/2020	**1210**	892	318	0.40	0.40	0.05	0.21

Figure 1: APPLE Load Test Drop Weight System with Top-Loading Transducer – Phase 1

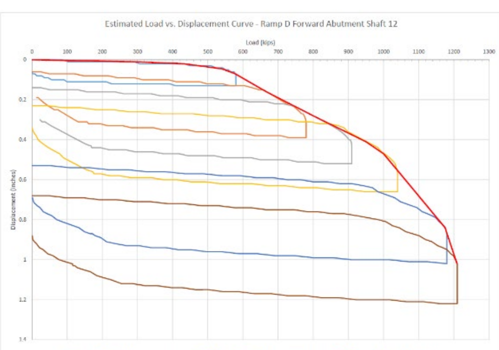

Figure 2: Data results from Dynamic Load Tests on Drilled Shaft – Phase 1

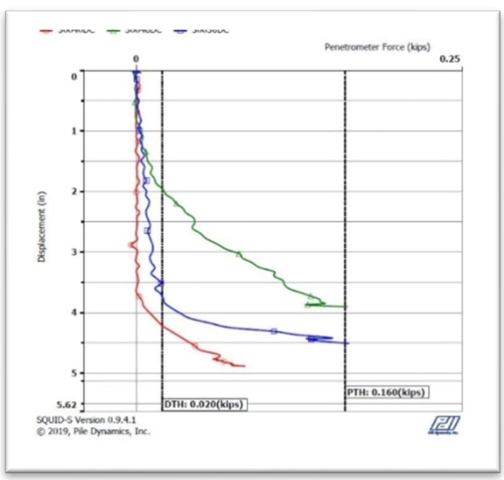

Figure 3: SQUID test results indicating dense soils at the shaft toe – Phase 1

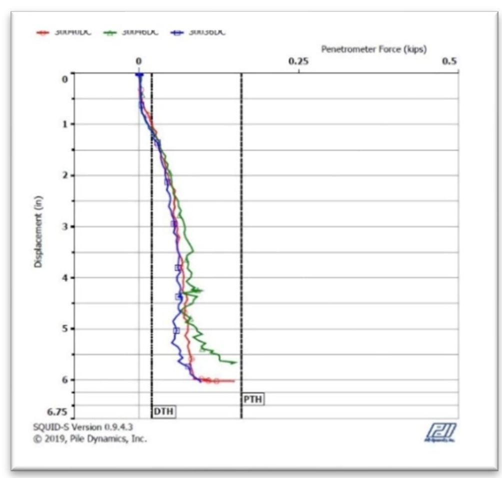

Figure 4: SQUID test results indicating very little soil strength at the shaft toe – Phase 1

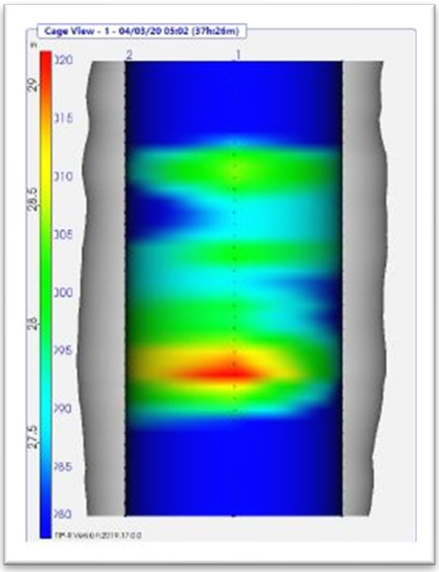

Figure 5: Thermal Integrity Profiling results, thermal view of concrete inside and outside the reinforcing cage – Phase 1

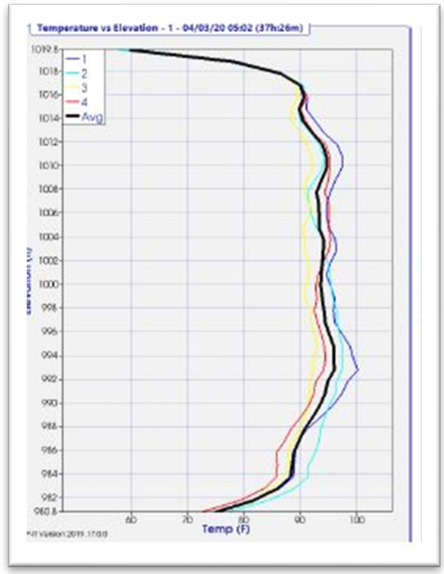

Figure 6: Thermal Integrity Profiling results, temperature vs elevation – Phase 1

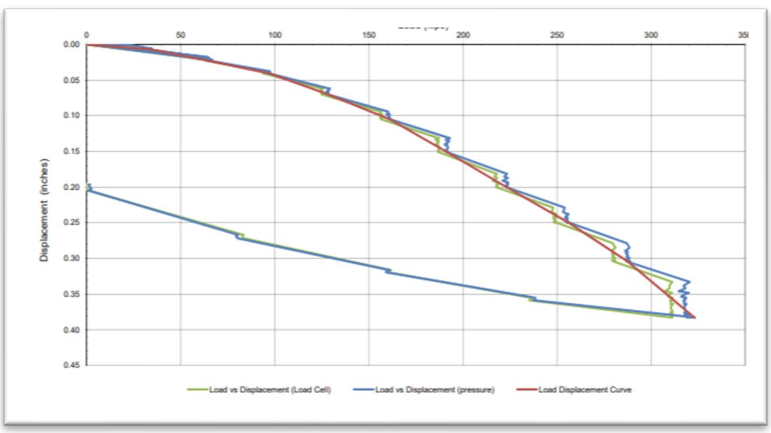

Figure 7: Data results from Static Load Test on ACIP Pile – Phase 3

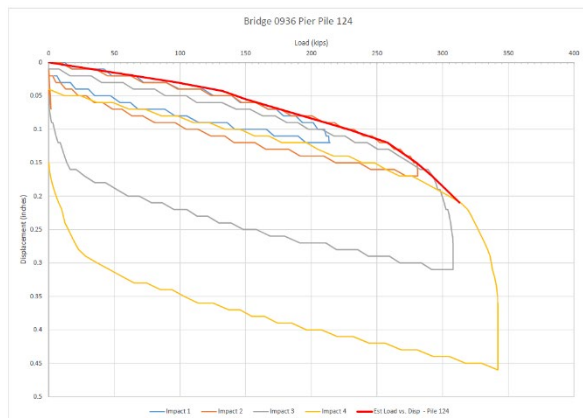

Figure 8: Data results from Dynamic Load Tests on ACIP Pile – Phase 4