NEW JERSEY TURNPIKE WIDENING PROGRAM

Remote dynamic pile testing yields savings

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As is the case of highways that cross metropolitan areas throughout the country, traffic on the New Jersey Turnpike has been increasing in recent years, leading to more frequent instances of traffic congestion. According to an extensive study, by the year 2032, the New Jersey population will have grown by 17.5 percent from its 2005 levels, while employment in central New Jersey will have increased by 28.2 percent during the same period. Higher volume of goods moving from Port Newark and Port Elizabeth as well as expansions at the Port of New York/New Jersey and at Newark Liberty International Airport will contribute to the continuing upward trend in traffic. By 2032, northbound traffic volume is expected to have increased by nearly 68 percent, while southbound traffic is forecasted to have increased by a whopping 92 percent.

The New Jersey Turnpike Interchange 6 to 9 Widening Program addressed these future traffic needs with approximately 35 miles of road widening, interchange improvements and bridge and ramp construction, from the vicinity of Interchange 6, in Mansfield Township, Burlington County to just south of Interchange 9 in East Brunswick Township, Middlesex County.

The program includes:

- Widening the Turnpike from six to 12 lanes from a point approximately two miles south of Interchange 6 to the existing 10-lane "dual-dual" roadway south of Interchange 8A. This will require adding a new three-lane roadway in each direction for a 25-mile section of the Turnpike (Milepost 48 to Milepost 73). The final result will be a dual-dual facility consisting of three "cars/trucks/buses" lanes and three "cars only" lanes in each direction.
- Adding a third lane to the existing "cars/trucks/buses" lanes in each direction of the 10-lane dual-dual roadway between Interchanges 8A and 9, a 10-mile section between Milepost 73 and Milepost 83
- Improving connections to interchanges and service areas, relocating and expanding the Interchange 8 Toll Plaza and associated ramps and widening Interchange 7A existing Toll Plaza

When complete, the proposed New Jersey Turnpike Widening Program will result in a 12-lane (six in each direction) dual-dual roadway from Interchange 6 to Interchange 9, capable of accommodating projected traffic needs through the year 2032. It will add 170 lane miles at a cost of about $2.5 billion.

Section 6 – Preconstruction photograph of Interchange 8 located west of the New Jersey Turnpike in East Windsor. A new Interchange 8 will be built on the east side of the New Jersey Turnpike during the Interchange 6 to 9 Widening Program.

A view of the New Jersey Turnpike, ramps and the new Interchange 8. In January 2013, the new interchange opened and the old interchange closed.

Figure 1: PKF piling crew driving production piles, Contract 605

A portion of the Widening Program, including the construction of 25 bridges for contracts 402 and 605, was awarded to PKF-Mark III, Inc. of Newton, Pa. PKF-Mark III is a site/civil contractor in the heavy concrete, foundations, electrical, process mechanical and heavy hauling industries. Between April 2011 and June 2013, PKF installed 17,729 LF of 16-inch cast-in-place pipe pile and 7,368 LF of HP14x117 pile for contract 402 and 67,947 LF of HP 12x53 pile for contract 605 (Figure 1).

Dynamic pile testing was specified for most of the bridge sub-structures during both initial driving and restrike. Dynamic pile testing, standardized by ASTM D4945, has been around for over four decades and is utilized widely on both private and public construction projects. This test method is embraced by the Federal Highway Administration and specified by most state Departments of Transportation on their bridge projects. The method involves attaching strain and acceleration sensors to the pile, recording their readings as the driving hammer impacts the pile, and analyzing the collected data by the Case Method and CAPWAP®. Historically, in order to perform dynamic testing, a testing engineer needed to travel to the project site, perform the testing, and then travel back either that evening and/or possibly the next day depending on the distance from home base. The cost of the engineer's required travel can be very significant, as much as one-third of the total cost of a one-day testing project depending on the travel distance. Even more critical, the required CAPWAP® analysis of data collected in the field, and reporting of results and recommendations, may be delayed because of the required travel.

Dynamic pile testing systems with remote capabilities have been available for almost a decade, allowing engineers to avoid travelling to the testing site. Systems such as the Pile Driving Analyzer® (PDA) shown in Figure 2, developed by Pile Dynamics, Inc., rely on cell phone technology that was at first somewhat slow to transmit data from the field and often spotty in remote areas. Consequently, remote testing was embraced by some, but, as is the case with many new technologies, it also experienced considerable resistance. Over the last few years, the technology has been refined, cell phone coverage has become more extensive and cellular data transmission has become extremely fast, allowing a testing engineer to remotely observe all hammer impacts in real time. Remote dynamic pile testing, now referred to as SiteLink®, has become a cost effective alternative to having a testing engineer in the field.

GRL Engineers, Inc. submitted two alternative cost proposals to PKF to perform the specified dynamic testing. One assumed

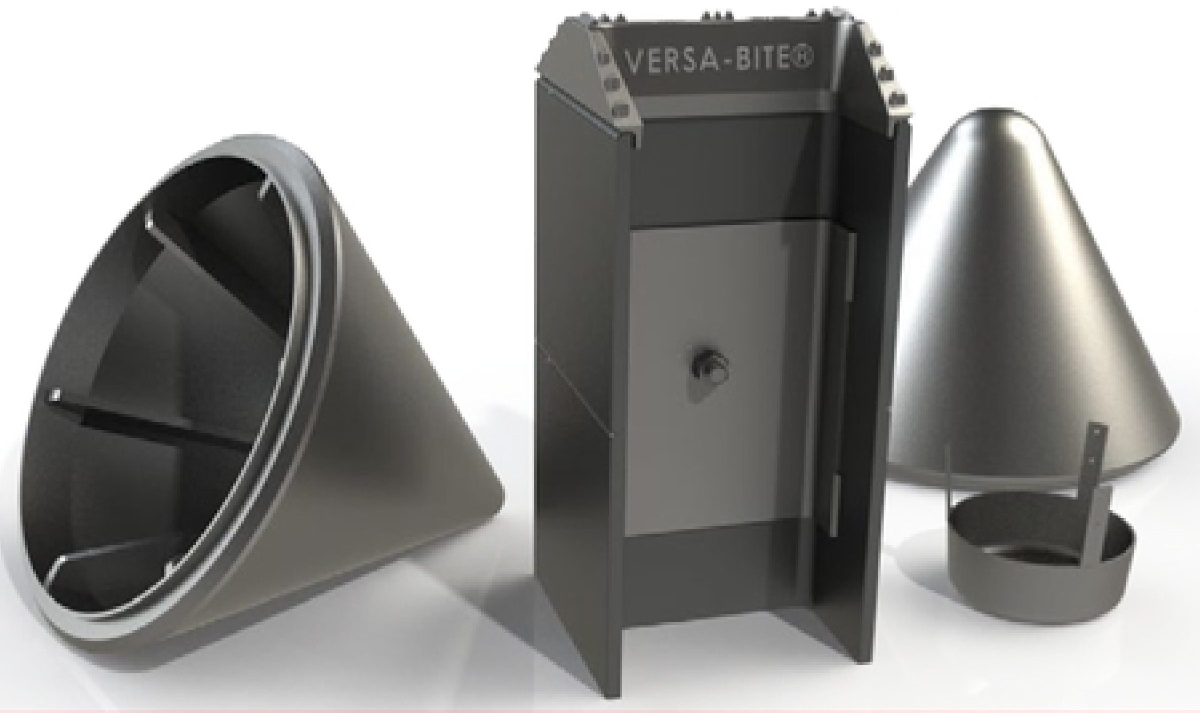


Figure 2: SiteLink® remote system with wireless sensors

Figure 3: Pile Driving Analyzer® during restrike testing

that an engineer would be on site, while the other proposed the SiteLink remote option. The latter would require PKF personnel to attach the sensors to the pile and set up the PDA, while data monitoring would be performed in real time by the GRL engineer in a remote office.

After evaluating the proposals, PKF made the decision to use the SiteLink option due to the significant savings it provided. This option eliminated scheduling conflicts and the need for travel of an engineer to the field to conduct the test, which in turn reduced costs and the time of report submittal. The construction crew would be trained to set up the instrumentation and initiate the SiteLink software on the PDA. A GRL engineer would monitor the job remotely using software that tracks and controls the pile test, and communication between the jobsite and office would be maintained during the test. Since the engineer would be able to monitor all parameters and control the PDA remotely on the office computer screen in real time, the testing would be conducted as if the engineer were in the field.

Dynamic testing was required during initial driving of all test piles, and also during restrike testing after a minimum 24-hour waiting period (Figure 3). Restrike tests aimed to evaluate the potential soil set-up, since the substrata often consisted of fine-grained soils that can lose significant strength during initial driving operations due to increased pore pressure and/or remolding. As this lost strength is typically regained with time, restrike testing is critical in obtaining a more representative long-term soil strength. Considering soil setup can therefore result in substantial savings in the foundation.

Restrike testing of the piles of this project most often indicated increases in capacities from soil set-up ranging from approximately 100 kips after an overnight wait to as much as 350 kips after longer waiting periods. Testing results of one such case are shown in Table 1. In this case, pile TP3 in Bridge 16 of contract 605 was tested during initial driving and during restrikes after one day and four day waiting periods. This pile had a Case Method mobilized capacity of only 203 kips at end of driving at an observed blow count of only 19 blows/ft (with an ICE® I-30 diesel hammer operating at an average stroke of 7.7 ft). Restrike testing after the required minimum 24-hour wait indicated a substantial increase in capacity, to 448

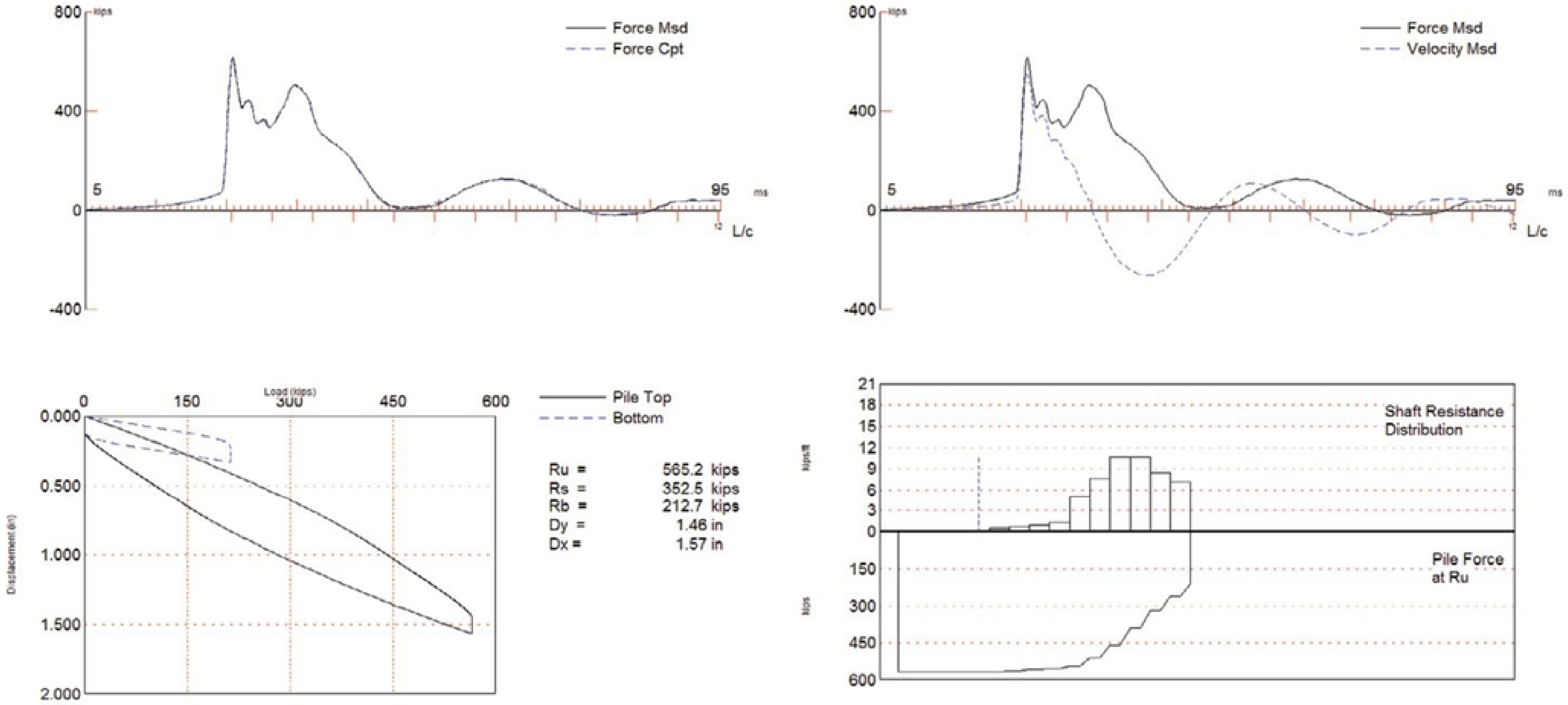


Figure 4: Graphical output from CAPWAP® analysis from BOR2

kips, with the reported blow count increasing to 8 blows/2 inches (48 blows/ft equivalent). As the required ultimate capacity of 477 kips was still not obtained during the restrike, and since the soil set-up was very dramatic even after only a one-day waiting period, a second restrike test was performed (see BOR2 in Table 1). This restrike testing after three more days showed a capacity of 560 kips (an additional gain of 112 kips and a 357 kips gain from the initial capacity) with the observed blow count increasing to 18 blows/2 inches (108 blows/ft equivalent). It is worth noting that the hammer stroke and energy transfer of this single acting diesel hammer also increased with resistance during the restrike testing. The measured compressive stresses near the pile top at the location of the sensors ranged from 31 to 38 ksi, and remained within recommended limits.

As a result of the restrike testing, the production piles were generally driven to at or near the design tip elevation, avoiding increased costs arising from the need to utilize longer piles.

A subsequent CAPWAP analysis (Figure 4) was performed on data measured during the second restrike to refine the results. CAPWAP analysis uses a data matching procedure which, when completed, gives information on the soil resistance distribution among other parameters. Note on the lower left of the figure that

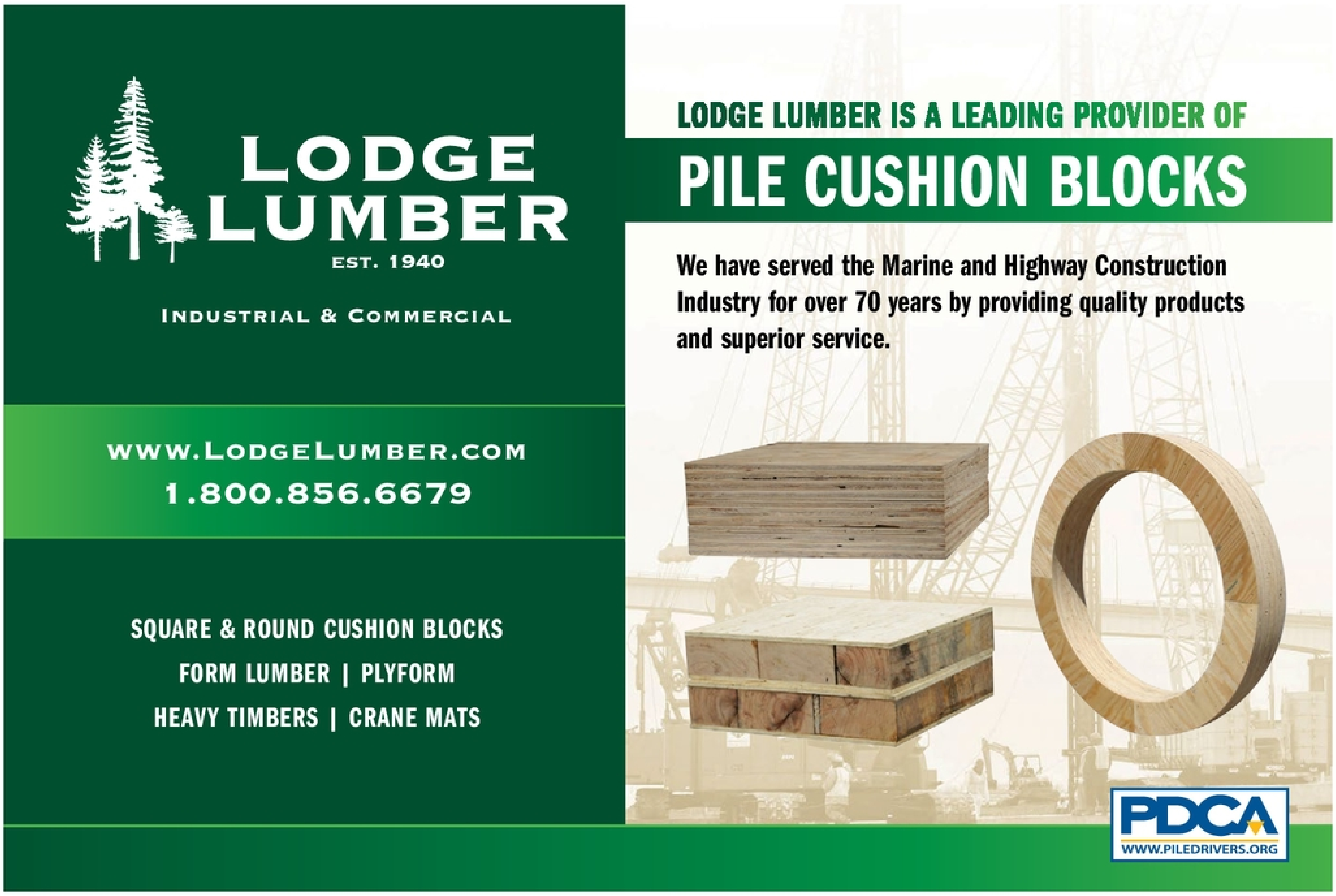
> **Since the engineer would be able to monitor all parameters and control the PDA remotely on the office computer screen in real time, the testing would be conducted as if the engineer were in the field.**

Table 1: Summary of Case Method Results
Project: NJTPK Interchange 6-9 – Contract #605

Bridge 16 (Str. No. 68.0ISO)

Pile No.	Sub Structure Designation	Test Date	Test Type	Penetration Depth (ft)	Blow Count (blow/set)	Hammer Stroke (ft)	Transf ‘d Energy (kip-ft)	Max Compressive Stress (ksi)	Case Method Capacity (kips)
TP3	South Abut.	12/12/12	EOID	66.3	19/ft	7.7	24.5	31.4	203
		12/13/12	BOR	66.3	8/2-in	9.2	36.6	35.2	448
		1/16/13	BOR 2	66.8	18,16/2-in	10.4	41.2	38.3	560

BOR: beginning of restrike or redrive; EOID: end of initial drive; EOR: end of re-drive



the mobilized capacity was 565 kips distributed as 353 kips friction and 213 kips end bearing.

Figure 5 shows a summary of the dynamic testing performed on contracts 402 and 605. Sixty-one initial drive tests and 75 restrike tests were performed for contract 402, totaling 56 days of dynamic testing. For Contract 605, a total of 73 initial drive tests and 92 restrike tests were performed over 90 days of testing. Figure 5 also shows approximate costs of performing dynamic testing remotely versus the cost of having a testing engineer on site for each test. The cost savings resulting from performing the testing remotely ranged from 28 to 35 percent, even before including construction cost savings realized from expedited results. Having results submitted on the same day as the testing allowed construction to continue without delays.

In quoting the PKF personnel's view of remote testing, "Overall, the SiteLink program was a great success. The means of testing on the site at any time is remarkable for the rapid changes we are faced with in construction. The SiteLink equipment was nothing more than a mobile computer and a few sensors, and the program was very user

Contract 402 – Remote PDA Test Summary

- 61 initial drive tests
- 75 restrike tests
- 56 days of POA testing → **Standard on-site cost: $83,000**

Actual remote testing cost: $60,000

Saved 28%

Contract 605 – Remote PDA Test Summary

- 73 initial drive tests
- 92 restrike tests
- 90 days of POA testing → **Standard on-site cost: $133,000**

Actual remote testing cost: $87,000

Saved 35%

Figure 5: Cost comparison of standard and remote testing using SiteLink

Performing dynamic testing during restrikes avoided the need for longer piles and contributed to keeping costs in check.

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friendly. A GRL engineer was always in reach by phone in case of any questions or concerns, which made it feel like the expert was on site."

Performing dynamic testing during restrikes avoided the need for longer piles and contributed to keeping costs in check. SiteLink remote technology, which has advanced to be a very useful and cost-effective testing option and was utilized throughout the project with practically no equipment or connectivity issues, was essential to reduce costs even more. In addition cost savings from avoiding travel, remote testing allowed the testing engineer to typically analyze the data and submit a report immediately following the test. This, in turn, allowed the contractor to quickly submit results to the owner for approval so they could continue to drive production piles with limited or no delay.

GRL Engineers and PKF-Mark III Construction are proud to have successfully collaborated to perform the large amount of dynamic testing required for the New Jersey Turnpike Interchange 6 to 9 Widening Program. ▼