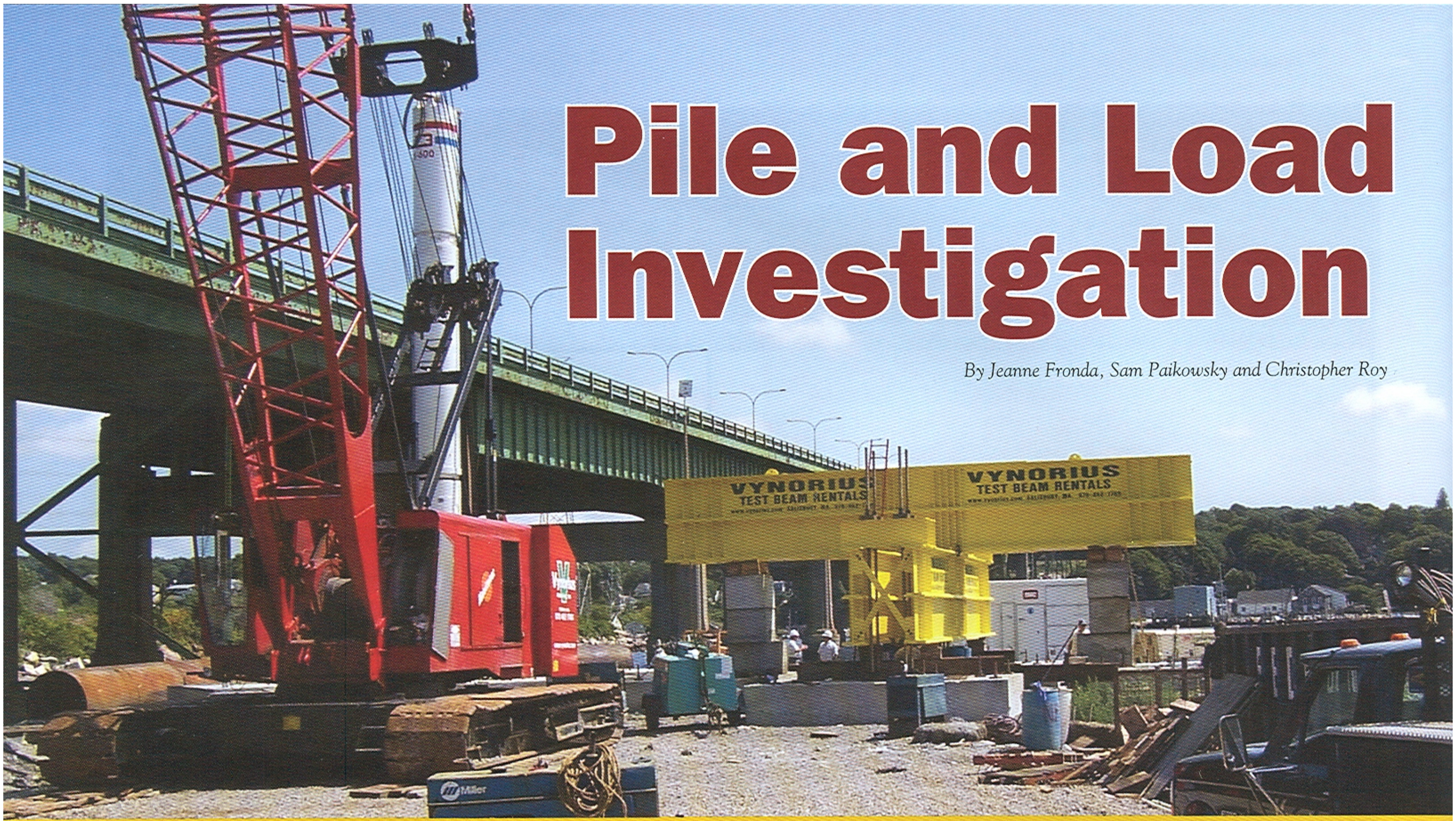
Pile and Load Investigation

By Jeanne Fronda, Sam Paikowsky and Christopher Roy



Innovative static load test points to savings for the Rhode Island Department of Transportation

The Sakonnet River Bridge is in Tiverton, R.I. Built in 1956 as a replacement for the Stone Bridge, the four-lane truss structure stretches across the Sakonnet River Bridge and supports I-24 and I-138 between the communities of Tiverton and Portsmouth, R.I. By the late 1990s, the bridge's design was obsolete, so it needed improvement. The bridge is scheduled to be replaced using a modern design, with construction work scheduled to start in 2008 and finish in 2015.

Introduction

Given the soil conditions at the new Sakonnet River Bridge site, the Rhode Island Department of Transportation (RIDOT) chose a deep foundation solution for the bridge replacement through a series of test programs. The first test program was performed by Vynorius Piledriving who was a subcontractor of Barletta Engineering. This initial test program consisted of an H-Pile, a 42" pipe pile and a drilled caisson. Favourable results where not achieved with any of these options precipitating the need for a second test program. As the company contracted to conduct the second test program, Cardi Corporation again chose Vynorius Piledriving to perform the majority of the work needed to complete the contract. The successful second test program resulted in the largest static load test ever conducted in New England.

Soil Conditions

The main obstacle for this site is the Rhode Island area glacier deposits that contain a generous amount of silt. Since the bedrock is deep and there is no bearing soil, a very deep foundation would be required.

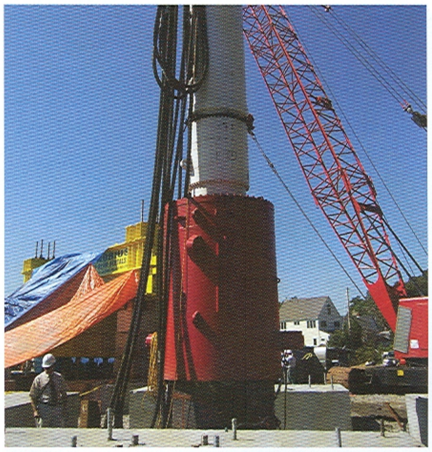
Samuel Paikowsky, a geotechnical engineering consultant with Geosciences Testing and Research and a professor at the University of Massachusetts at Lowell, was hired by Haley & Aldrich Inc. of Boston to design an economical deep foundation solution for the soil conditions encountered at this site.

"This is an extremely interesting project, because you had a difficult combination," says Paikowsky. "You had a large bridge, which resulted with heavy loads to carry combined with soils, which are very problematic. The challenge is to find a solution that can be constructed economically knowing that in the past there were major failures."

Paikowsky designed an innovative variation to the common open-ended pipe pile. Given the current cost of steel, pipe piles are very expensive. The longer or larger in diameter the pipe piles are the more expensive the project will be. Paikowsky developed a design to artificially plug an open-ended pipe pile, which would increase its static capacity and shorten the penetration required to achieve the desired design capacity, saving this project a significant amount of money. The manager of the project was Heather Scranton, and engineers Jean Louis Locsin and Michael Capraro with Haley & Aldrich Inc. were also involved with the testing.

Test Design

The second test program was comprised of two stages. During the first phase two 72" diameter pipe piles were



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— Samuel Paikowsky, geotechnical engineering consultant with Geosciences Testing and Research

driven to a depth of 133 feet. The first pile was a standard open-ended pipe pile; the second had a prefabricated plate installed acting as a "plug." The plug was installed 40 feet from the pile tip and was comprised of a 2" thick plate with a 14" hole in the center. The design was aimed for the soil to create a plug at a desirable depth while providing sufficient penetration to resist lateral loads. The piles where driven with an IHC S-600 hydraulic impact hammer with a maximum rated energy of 443,000-foot pounds. A static test was then performed on both piles. The open-ended pile failed at a capacity of 2,500 kips and the plugged pile achieved a sustainable load of 4,500 kips. During the second phase of the testing program, the open-ended pile was extended and driven to a depth of 235 feet, the "annulus" pile was driven to a depth of 187 feet. Both piles were again statically tested. The open ended pile achieved a load of 5,500 kips and the annulus pile showed no sign of failure under the desired load of 6,000 kips, the maximum possible applied load.

Designed by Richard Pizzi of Geotechnical Consultants Inc., the 6,000-kip reaction frame involved two 1,500-ton reaction beams, four 17 x 10 foot concrete pile caps and forty 150-kip tie-downs. The tie-downs were installed in four groups of 10. Each tie-down group was cast into a 17-foot x 10-foot concrete cap. Each cap had 2.5" diameter Williams rods extending from the pile cap up to the reaction beams. The reaction beams were set one atop the other to form an "X." Four 1,800-kip jacks were utilized to create the 6,000 kips load needed for the test.

As mentioned, the silty soil conditions were problematic, making standard H-beams ineffective to anchor the frame. Tie-down anchors where thought to be the better option. There

were still concerns about whether or not the tie-downs could hold such a large capacity and how they would react in that soil condition. Two tie-downs were installed and tested to the desired load. Production installation was monitored such that the tie-downs were installed using uniform or consistent grout volumes and water pressures.

"We were proud to have the opportunity to complete the largest load test in New England," says Christopher Roy, the estimator with Vynorius Piledriving Inc.

Material and Machinery Used

A Manitowoc 4100 Series 2 crane was used onsite and an IHC S-600 hydraulic impact hammer, with a maximum rated energy of 443,000 foot pounds and a hanging weight of 100 metric tons, was used to drive the piles.

The hydraulic jacking system used, which consisted of four 1,800 kip double acting hydraulic jacks, was designed and provided by WB Equipment Service Company Inc.

The tie-down materials were provided by Williams Form Engineering and were installed by Terra Drilling. A Casagrande hydraulic track mounted drill rig was used to drill the holes for the tie-downs. A double drum mixer with a Moyno pump was used to site-batch the grout that filled the holes.

Logistical Problems

The site selected for testing was rather small, as it was at the edge of the river adjacent to the existing Sakonnet River Bridge. So access into that area included some narrow roadways that were near a residential area. The load frame had to be transported in pieces and trucked in so it could be assembled onsite. As many standard pieces as possible were used along with multiple W36 wide flange sections. In total, eight different components were used to build the modular frame.

"It was very interesting and challenging. It's a large public works project with a lot of people reviewing it, a

lot of different engineers, and it's always a challenge to please them," says frame designer Richard Pizzi with Geotechnical Consultants Inc., Vynorius' design engineer.

"This is the way foundations should be designed. Years ago when we started we really didn't have the sophisticated tools that we have for predicting pile capacities, so we always did a load test at the beginning of a project and used the results of that load test to then prepare the foundation design. This is reverting back to the way we used to design piles, and in the long run it's a much more efficient, much more equitable way of designing the piles than has become customary for most projects that we do.

"This test program is certainly successful and certainly in my opinion, the right way of going about designing a difficult and costly foundation to ensure that we get the most and best information that we can."

Paikowsky agrees that those in the industry should seek cutting-edge foundation solutions.

"I am very proud of this project," he says. "I think it's the way we should move in the future. If we want to save the state money, we have to try and look for more innovative solutions. I'm extremely happy. I had the opportunity to offer it, to test it and now to implement it for construction."

The first test contract ended approximately in October 2006, while the second test began in April 2007 and testing was completed in November 2007. The new bridge replacement is estimated to begin in summer 2008 using the shortened annulus fitted pile that provides high resistance in a shallower depth compared to the simple open-ended pile. ▼