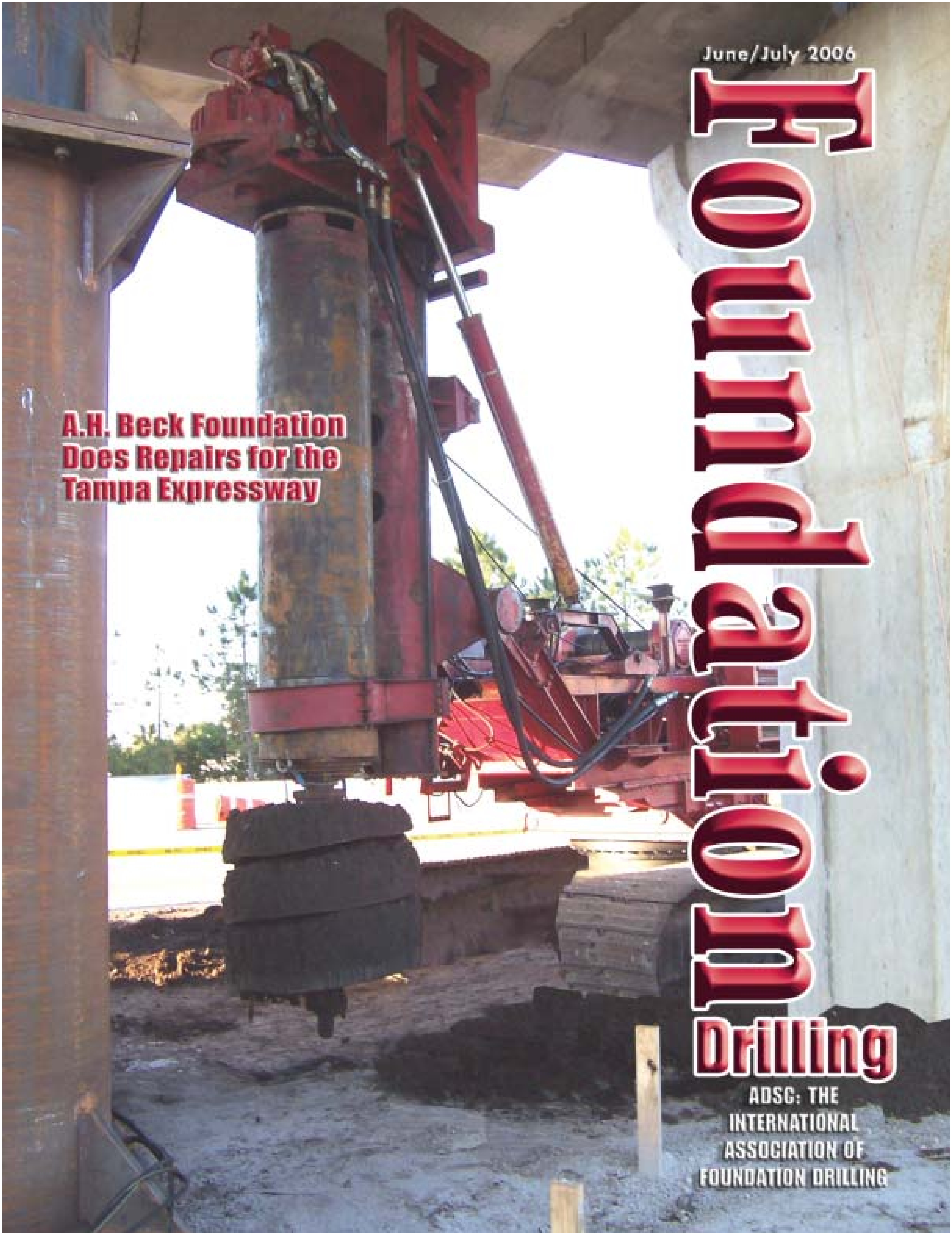

June/July 2006

Foundation Drilling

A.H. Beck Foundation Does Repairs for the Tampa Expressway

ADSC: THE INTERNATIONAL ASSOCIATION OF FOUNDATION DRILLING

Under the Crosstown:
Remediating the Drilled Shaft Foundations for Tampa, Florida's Lee Roy Selmon Crosstown Expressway

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Foundation failure at Bent 97 - April 13, 2004. Photo courtesy of PCL Civil Constructors.

In 1999, the Tampa-Hillsborough Expressway Authority developed a plan to reduce congestion and commuter time between Brandon, Florida and downtown Tampa by building a special Reversible Lanes Bridge in the median of the existing Lee Roy Selmon Crosstown Expressway. Traffic on the new three-lane expressway would flow one way during rush hour into downtown, and then reverse the flow of traffic in the opposite direction during evening peak times.

Investigators would later discover that major remediation efforts were required for 68 of the bridge's original 224 foundations as well as the installation of 14 foundations not completed prior to the start of remedial work.

The idea attracted positive attention for numerous reasons. Financially, taxpayers would not have to pay for the bridge, as the project would be funded by tolls collected on the Selmon Expressway. Commuters would enjoy shorter drive times, as well as panoramic views overlooking the city, the Port of Tampa, the Palm River and adjacent wetlands. The bridge would be functional as well as aesthetically-pleasing.

Initial construction began in February 2003, but was abruptly halted in April 2004, when one of the support piers plunged into the ground, dropping two adjoining bridge spans. Investigators would later discover that major remediation efforts were required for 68 of the bridge's original 224 foundations as well as the installation of 14 foundations not completed prior to the start of remedial work. (For this project, a "major" remediation was classified as a foundation with a calculated capacity 1,000 tons or more below the required capacity.) These foundations were to be repaired by installing two 48-inch diameter sister shaft foundations to varied depths. The new sister shafts would be tied to the deficient shafts with post tensioned caps. A. H. Beck Foundation Co., Inc. an ADSC Contractor Member and a specialist in complex foundation drilling applications – was selected to perform the repairs under the management of PCL Civil Constructors, the project's general contractor responsible for remediation oversight. Over the course of the next year, BECK would often draw upon its nearly 75 years of experience to devise special equipment modifications that could encompass the changing needs of this unique project.

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Background

During the first 14 months of the initial construction, 204 foundations were constructed to an average depth of 61 feet below ground, while two miles of segmental bridge was erected on nearly half of those foundations. On April 13, 2004, within hours after placing the last bridge segments on the span west of Pier 97, the pier plunged 11 feet into the ground, dropping the completed span to the east and the loose segments and the erection girder spanning to the west. Fortunately for both bridge workers and motorists on the adjacent roadway, the bridge remained intact under the tremendous stress induced by the settlement, thereby avoiding any related injuries or accidents.

The Expressway Authority's geotechnical advisors first assumed that the failure was caused by an undetected geologic anomaly (a "sinkhole") 70 feet or more below ground, below the Pier 97 foundation. The Authority contracted with Ardaman & Associates, an ADSC Technical Affiliate Member, and a nationally recognized engineering firm specializing in geotechnical engineering and foundation design, to perform an independent "forensic" analysis to determine the cause of the settlement. However, explorations required to evaluate the subsurface conditions could not be done until the dropped spans were removed. (In the meantime, work continued in other areas of the project, including skipping over Pier 97 and starting the span from Pier 98 west to Pier 99.) At Ardaman's recommendation, a program of geophysical exploration was initiated to evaluate the continuity of the "bearing stratum." This exploration would detect any anomalous conditions that could affect the drilled shaft foundations and was necessary so the bridge could be completed over I-75, closing the eastern part of the construction.

On July 6, 2004, Pier 99 settled 1.3 inches during the placement of the last bridge segments for the span west of the pier. Although this amount of settlement might seem small, the settlement was more than the bridge's designers had deemed allowable, and

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Remediation work being done on shafts out in the Palm River.

BECK designed and built concrete pump placing concrete into shafts with overhead restrictions.

Even the areas with no overhead obstructions were tight to access and difficult to maneuver through because of the existing structures and foundations.

the pattern of settlement indicated that the strength limit of the drilled shaft may have been reached. The Authority now became concerned about the integrity of *all* the deep foundations under the structure. The Authority ordered an immediate halt to construction on the bridge and expanded Ardaman's responsibilities to include evaluation of all of the existing 204 foundations. By September, Ardaman reported its conclusion that the drilled shaft supporting Pier 97 was founded in a weak formation consisting of interbeded weathered rock lenses and soil, not competent limestone. Ardaman's forensic investigation conclusively determined that there was no structural flaw or failure in the Pier 97 foundation before or after the settlement; the failure had occurred in weak soil and rock supporting the foundation.

Ardaman eventually determined that 52 of the piers were deficient (20 under the existing bridge and 32 where the bridge had not been built yet) and needed remediation with additional drilled shaft foundations. BECK was hired based on this initial assessment; however, as engineers collected more geotechnical data at each pier location, the requirements continued to grow. BECK would ultimately wind up installing sister shaft foundations on 28 piers under the existing segmental bridge (with depths ranging from 50 feet to 90 feet) and 39 piers where the bridge had not been built yet (with depths ranging from 50 feet to 112 feet) – for a total of 149 new drilled shafts installed (14 piers had no drilled shafts installed before the remedial work started).

Boosting Productivity Through Technology

By the time remediation efforts were finally started, the project had been delayed for almost a year, and the owner needed to complete the repairs to the existing foundations as well as the remainder of the bridge construction. Obviously, no work could be constructed overhead until the remediation of the existing foundations was complete.

Typically, two 48-inch diameter sister shafts with depths of up to 90 feet were installed at each deficient pier to remediate the foundations. At the locations where the segmental bridge had already been built, the sister shafts were put in place with as little as 18 feet of overhead clearance and in a 45-foot wide median between the existing at grade lanes of the toll road. In fact, even the areas with no overhead obstructions were tight to access and difficult to maneuver through because of the existing structures and foundations. Clearly, none of the remediation work was going to be completed quickly.

To speed up the installation process, BECK utilized several unique procedures and equipment that it designed and manufactured:

1. Use of modified casing oscillators to install and extract the tempo-

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Casing being extracted after concrete placement.

rary casings needed to install the sister shaft foundations.

2. Use of high capacity, low overhead drilling equipment.

3. Use of a patented concrete pumping system.

Temporary segmental casing was to be installed through various layers of poorly graded sands, gravelly sands, weight of hammer (W.O.H.) material, weathered limestone, and, finally, to limestone. The casings were composed of 40 mm thick walls and approximately 9-foot long interlocking sections.

In order to stay on schedule, BECK made use of two of its self-designed casing oscillators to advance the casings. One was placed in tight areas out in the open, and one was placed under the bridge. An additional drill crew utilized an American Pile Equipment* APE 200 vibratory hammer to install and extract the casings where there was sufficient working room in the open.

The casing oscillators were attached to a track mounted hydraulic crane that had a modified boom. They were used to advance the segmental casing in three meter joints under the existing bridge. The oscillators were ideal for this project for several reasons:

1. to reach the varying elevations of the limestone and the pockets of soft material within the limestone (even in the areas with no overhead restrictions),

2. to operate under the low clearance of the bridge, and

3. to extract the casings once concrete was placed (so as not to affect the shaft capacity).

In some locations, pockets of weight of hammer (W.O.H.) material were discovered in the limestone, necessitating the use of a special cutting shoe placed on the bottom of the segmental casing. The cutting shoe was used to advance the casing through the upper limestone lenses, the W.O.H. material, and then back into competent limestone.

Since this project required many

BECK-modified casing oscillator used to advance casings down to the limestone.

manhours in low-clearance, limited access site conditions, state-of-the-art equipment such as the casing oscillators, vibratory hammers and cutting shoes significantly boosted worker productivity and efficiency. As a result, the sister shaft foundations were installed in much less time – and thus less expensively – without sacrificing quality.

On-the-Fly Equipment Modifications

After the temporary casings were installed, the shafts were drilled with water, forming a natural slurry drilling fluid that was used to stabilize the remainder of the excavation. Due to the karst nature of the limestone, the shafts had to be monitored at all times to keep a positive head in each excavation. A low clearance drill rig – designed and manufactured by BECK – was used to excavate the foundations. The drill rig was originally designed to excavate the 48-inch diameter shafts to depths of 70 feet, but as the remediation designs progressed and additional soil information was collected, engineers discovered that some of the sister shafts would need to go much deeper than

To accommodate the new requirements, BECK modified one of its existing low clearance drill rigs to excavate to depths of up to 90 feet.

the original estimate of 70 feet. To accommodate the new requirements, BECK modified one of its existing low clearance drill rigs to excavate to

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BECK-manufactured hydraulic crane attachment mounted on a Northwest 5045 working on remediation shafts with no overhead obstructions.

depths of up to 90 feet.

After the excavation was completed, the shafts had to be cleaned and then inspected with a Shaft Inspection Device (SID). Since the project called for stringent bottom of excavation cleanliness, BECK utilized a unique cleaning device attached to a 4-inch hydraulic submersible pump. This device vacuums sediment off the bottom of excavations. It had been developed by BECK for a previous project with similar specifications that also required SID inspections. The device functioned well, cleaning the bottom of the excavation so that all requirements of the SID inspection were met in a timely manner for most of the new foundations. However, in a few situations, the cuttings were in cobble-sized fragments of hard limestone and could not be removed by either the auger or the vacuum device. Also, at times the socket was so soft that continued cleaning never got the tip of the shaft clean within FDOT specifications. In these instances, Ardaman reviewed the design intent and determined whether the shafts could support the design load in friction without depending on bearing. The drilling was then terminated, and the shafts were completed. In other cases, the foundation was drilled deeper until a more stable formation was reached,

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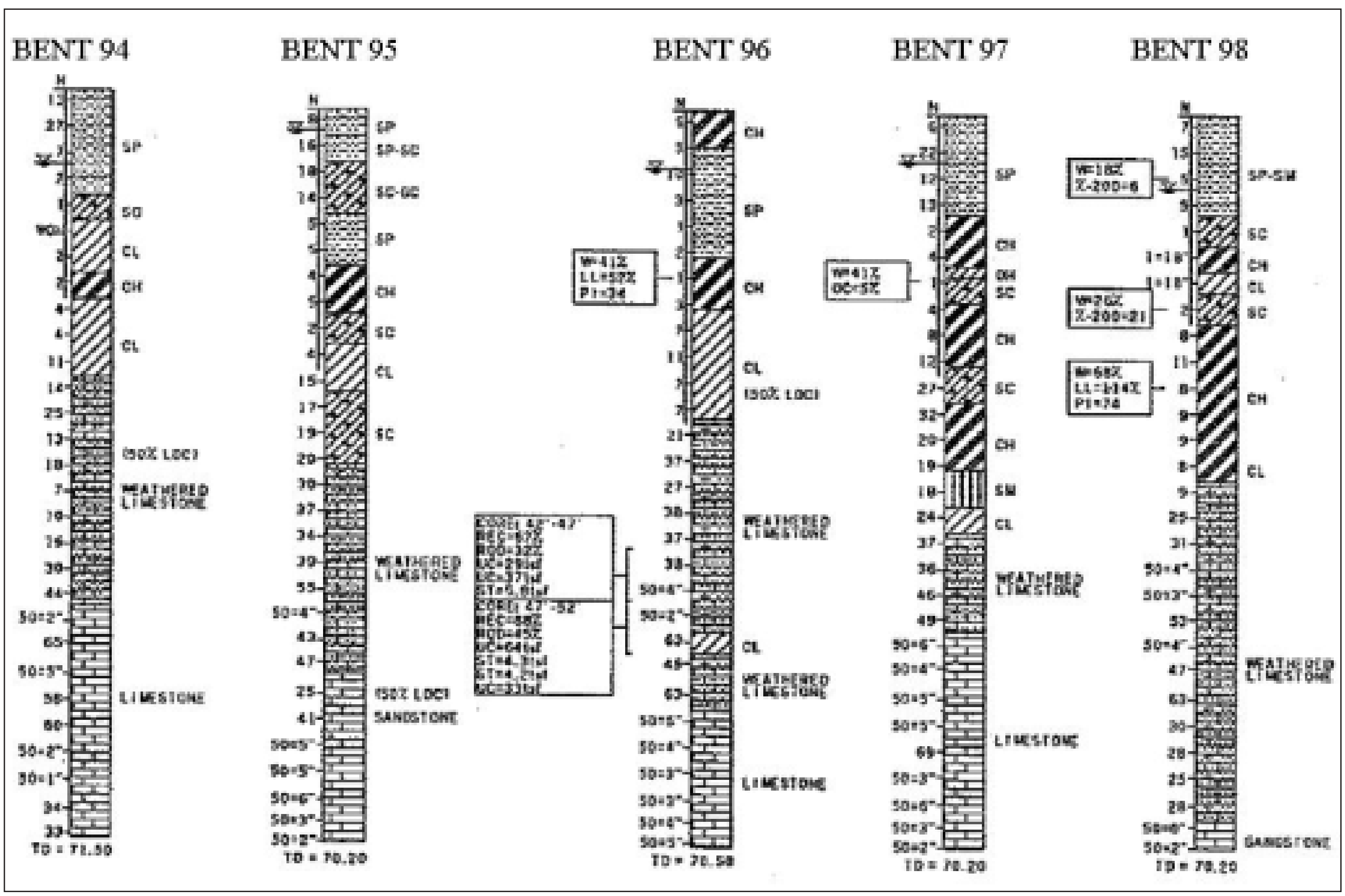

Rebar cage consisting of (12) #18 vertical bars being spliced together with mechanical couplers.

or until the deeper shaft could support the design load without depending on end bearing.

Next, steel reinforcing cages complete with Cross Hole Sonic Logging (CSL) tubes had to be spliced together over the excavation. Concrete was then placed with a concrete pump that was designed, constructed and patented by BECK. This pump was designed to provide a continuous flow of concrete to the bottom of the excavation under the overhead restrictions by pumping through 130 feet of 5-inch flexible hose that is reeled up and lowered down into the excavation. By providing a continuous flow of concrete into the excavation, the placement time was significantly reduced over conventional low overhead concreting options, and the possibility of tremie breaches or concrete lockups was minimized, thus resulting in a high quality foundation. After placing the concrete, the integrity of all of the shafts was inspected by Cross Hole Sonic testing.

Conclusion

Nearly 2-1/2years after the first pier sank into the ground, Tampa's Reversible Lanes Bridge is scheduled to open in August 2006. The remediation efforts took 14 months, but finished ahead of schedule because of BECK's specialized, highly productive equipment and its resourcefulness to modify this equipment as needed. Also key to the project's success was BECK's ability to design and build almost all of the necessary drill and support equipment. This provided a wide variety of options to the project so that the proper equipment could be matched with the suitable location. Such flexibility accommodated the changing conditions identified by Ardaman, based on analysis of data from the continuing exploration program and conditions observed during the foundation construction inspections. As a result, the citizens of Tampa, Florida will soon enjoy a very productive, cost-effective and high-quality bridge.■

PROJECT TEAM

Owner:	Tampa- Hillsborough County Expressway Authority
Structural Engineer:	Figg Bridge William Shealy – Assistant Project Engineer
Geotechnical Engineer:	URS Corporation Southern John Delashaw, P.E.
Remediation Consultant:	Ardaman & Associates, Inc.* Ross McGillivray, P.E. Dan A. Brown, Ph.D., P.E.
Remediation CEI:	Jacobs Civil Engineering, Inc. Scott Case, P.E. – Project Manager
General Contractor:	PCL Civil Constructors Scott Updegrave – Construction Manager Lynn Davis – Project General Superintendent Greg Fullington – Assistant Project Manager (Remediation) Greg Grady – General Superintendent (Remediation)
Specialty Contractor:	A. H. Beck Foundation Co., Inc.* Nathan Leyendecker – Project Manager Gary Phillips – General Superintendent Tim Beavers – Superintendent Ed Lopez - Superintendent

**Indicates ADSC members.*

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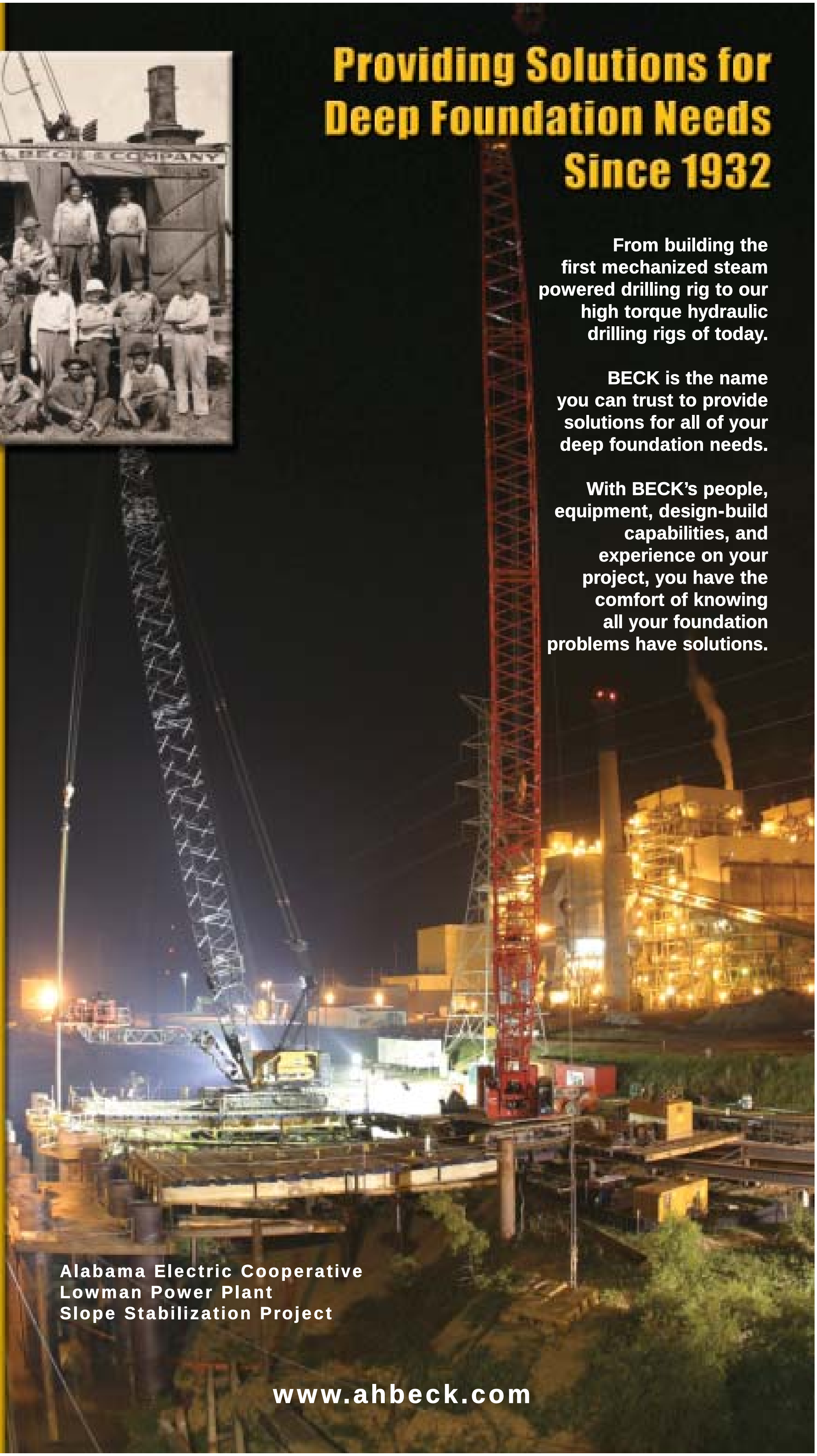

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