Chicago’s Navy Pier, originally called Municipal Pier, was constructed between 1914 and 1916 as a pre-cast concrete deck structure supported on timber pile foundations likely driven into the stiff clay and hardpan beneath the pier. The name was changed to Navy Pier in 1927 to honor naval veterans of WWI. As the wood piles aged and deteriorated over time, foundation repair work kept the pier functioning.

The pier has a checkered occupancy history. Burnham envisaged it as a dock for freight and passenger traffic and a venue for indoor and outdoor events. It also briefly served as a jail for draft dodgers in 1918, a training center for navy pilots (including former President George H.W. Bush) during WW II and was home to a branch campus of the University of Illinois, Chicago from 1946 to 1965. Following the relocation of University students to a new campus just west of downtown Chicago, periods of underutilization, brief revitalization, and decline came and went. That changed in the late 1980s with the creation of the Metropolitan Pier and Exposition Authority, which redesigned the pier as a vibrant mix of parks, gardens, restaurants, and exhibit facilities that opened to the public in 1995.
As the pier’s 100th anniversary approached, a bold new initiative—aptly named the Centennial Vision—was launched. This includes comprehensive redevelopment and pier-wide enhancements. The first phase was completed in the summer of 2016 and included a new Ferris wheel. Around the same time, work began on expanding the Shakespeare Theater. Current work includes construction of a seven-story hotel on the pier’s east end, slated for completion in 2019.

Expansion for the eastern portion of the pier revolves around building atop open water. This presents its own set of challenges. However, building on a pier dating back to the early 20th century also requires special construction considerations. The original pier’s roots of being an industrial shipping port were replaced long ago. Subsequent renovations replaced the industrial strength timber decking with maintenance free pre-cast concrete decking. This surface cannot safely support the additional concentrated loads imposed by the large, heavy equipment typically required for the drilled shafts that are often the deep foundation method of choice for Chicago’s iconic skyline.

“Expansion for the eastern portion of the pier revolves around building atop open water. This presents its own set of challenges. However, building on a pier dating back to the early 20th century also requires special construction considerations.”

DRILLED SHAFTS - A CHICAGO TRADITION

Chicago’s skyline has included many “firsts” over the years. The Hancock Building and the Willis Tower, formerly Sears Tower were heralded as state-of-the-art buildings when they were constructed. The Sears Tower reigned as the tallest building in the world from 1974 until 1998. These feats of architecture and structural engineering would not have been possible without the early use of large diameter drilled shafts, or caissons as they are often called on the typical Chicago construction site. The use of
rock-socketed shafts combined with excellent dolomitic limestone beneath the city allowed for the construction of the skyline. The shafts are often drilled through urban fill and at times debris from the Great Chicago Fire of 1871. Beneath the urban fill, foundation contractors and geotechnical engineers found a layer of native very soft clay (Chicago Blue Clay). The shafts would then be belled and rest on top of the competent glacial tills (hardpan), with more heavily loaded shafts extending through the hardpan and socketed into bedrock. Bedrock is generally about 100-ft below ground level. This foundation scenario has resulted in the growth of the City. However, on our subject structure, the Navy Pier, drilled shafts are difficult to construct due to the previously discussed weight limit on the decking material.

**ENTER MICROPILES**

The construction industry in Chicago is not about backing down when faced with a challenge such as access. When the Navy Pier Exposition Authority set about improving the amenities on the piers some 25 years ago, an alternative to the drilled shafts was required. At about the same time, micropiles were starting to become a commercially viable deep foundation alternative to drilled shafts in difficult and challenging conditions on the east and west coasts of the U.S. Micropiles are well suited for work in urban environments. The slender elements can be drilled through grillage foundations and old “wedding cake” footings that are common foundation elements for buildings that were constructed after the Great Chicago Fire. They can be drilled through these difficult conditions without vibration or loss of ground associated with open hole or driven deep foundations.

Micropiles made their first appearance in Chicago around 1990, closely followed by a small project on Navy Pier by

Continued on page 34
TCDI, now a part of ADSC Contractor Member Hayward Baker Inc. (HBI). The job involved just six 50-kip capacity friction piles for the repurposing of the original Headhouse structure as the new home of the Chicago Children’s Museum around 1993. And the rest, as they say, is history, with increasingly large and more complex micropiles playing a prominent role in many of the renovation and expansion projects on Navy Pier over the last 25 years.

PARKING GARAGE UPGRADE

The first significant micropile job on the pier was for expansion of the indoor parking facilities. HBI installed 7-inch diameter, micropile foundations with a 200-kip design load extending into the underlying dolomitic bedrock for the expansion. During drilling of these piles, a previously unidentified utility was pierced on Good Friday afternoon, 1997. This was a salutary, if very inconvenient, lesson for Chicago Geotechnical Engineers. Micropiles are well suited for drilling through difficult ground conditions, or in this case, an unmarked utility! Extra care has been taken in locating utilities and structures since this first utility strike. Much of the work on the pier has included drilling through not just the deck but often times different levels of the parking garages on the pier as well, hence the concern about drilling through structural members of the facility.

GARDEN SHOW SOIL OVERLOAD

The popular annual Navy Pier Garden Show, held in Festival Hall, requires significant importing of sand and soil destined for the showpiece exhibition gardens. The material is typically stockpiled in various locations within the lower floor of the venue. In 2001, the weight of material in one location caused a 20-ft by 60-ft section of floor to collapse into the parking garage below. Several cars were crushed when the deck gave way. Fortunately there were no reported injuries. HBI was called in to design and install ten, 7-inch OD, 200-kip micropiles up to 110-ft long in open headroom conditions and two 7-inch OD, 200-kip micropiles in limited headroom to support the damaged structure. All micropiles were socketed 2-ft into the underlying bedrock. This work was performed on an emergency basis to get the parking deck back into service.

MILLENIUM WHEEL

In the Spring of 2015, construction began on a new Ferris wheel on the roof of the Navy Pier precast parking garage. At 196-ft in diameter, the new wheel is larger than its predecessor on the pier, but by no means the largest Ferris wheel ever to grace the Chicago skyline. That honor belongs to the whopping 265-ft diameter wheel erected for the 1893 World’s Columbian Exposition.

Continued on page 37
The supports for the new wheel sit atop two pile caps, each supported by four micropiles. All the micropiles are designed for 200 kips of compression load and 200 kips of tension load. Significant challenges included high tension loads, HS-20 Department of Transportation weight restrictions, and the need to drill from the pier deck down through the parking garage air space since access to the garage itself was not available. Not only was smaller equipment required for the installation, but the driller was essentially installing the piles 30-ft “in the blind.”

SHAKESPEARE THEATER

As previously mentioned, in 1997, TCDI had performed a small micropile job for renovations to the Shakespeare Theater. In the Fall of 2015 crews were back, this time to install micropiles for planned expansion to allow for larger productions and larger audiences. The renovations incorporated 18 rock-socketed micropiles at six pile cap locations into the design. Each micropile was designed to support 266 kips in compression. The micropiles were installed from within the existing parking garage. With only 8-ft of headroom available at each pile location, HBI mobilized low-overhead drill rigs to install short, 3-ft sections of drill casing to a depth of approximately 100-ft, which included a 2-ft rock-socket.

NEW BOUTIQUE HOTEL

HBI is currently back on the pier installing micropiles for a new, 7-story hotel under construction on the east end, adjacent to and incorporating the historic Terminal Building. The structure was originally designed to be supported on drilled shafts. However, the initial foundation budgets were considerably higher than expected, with a significant portion of the foundation cost tied up in providing access for the large drilled shaft equipment. As discussed above, the decking simply could not support this equipment. Providing access would require replacing many of the deck panels. Given the company's previous experience with micropiles on the pier, HBI was approached by the general contractor, McHugh Construction and Thornton Tomasetti, the Structural Engineer of Record, to see if an alternative micropile foundation system was possible.

“Given the company’s previous experience with micropiles on the pier, HBI was approached by the general contractor, McHugh Construction and Thornton Tomasetti, the Structural Engineer of Record, to see if an alternative micropile foundation system was possible.”
If micropiles could be used for the new hotel, they would be among the highest capacity and most technically challenging micropiles ever installed in Chicago. Each column location for the hotel has over 1000 kips of vertical compression load and approximately 20 to 40 kips of lateral load. On conventional structures (those not constructed over open water) the lateral loads are transmitted into the soils surrounding the micropiles. In this case the micropiles needed to be installed through the concrete precast pier deck then through 22-ft of water before encountering the lake bottom. Water is, after all, not capable of taking lateral loads or for that matter vertical loads. After extending through the lake, the piles needed to be drilled through another 100-ft of soil before being socketed into rock.

For conventional micropile installation, the soil provides lateral support to the micropiles so that buckling is not a concern. The soil can also used to resist small to moderate sized lateral loads without the need to batter the micropiles. The hotel micropiles needed to be designed for an unbraced length through the water as well as the full lateral loads of a 7-story building. Battered piles at adjacent pile caps would overlap while extending 120-ft from the pile cap to the bedrock if not designed properly. Lastly, during drilling it is critical to have spoils return to the surface with the drilling fluid. Just as water does not provide lateral support, it also does not allow return of the flush to the surface.

When Navy Pier’s original wood foundations were installed there was no concern if debris or contamination entered the lake water. Of course, given today’s need for environmental awareness, HBI is required to prevent the drill spoils from entering the water. Working closely

Continued on page 40

THINK SAFETY FIRST

Do you need help understanding the Occupational Safety and Health Administration’s (OSHA) Respirable Crystalline Silica Standard for Construction? If so, this guide is for you.

Workers exposed to respirable crystalline silica are at increased risk of developing serious adverse health effects including silicosis, lung cancer, chronic obstructive pulmonary disease, and kidney disease. This guide describes the steps that employers are required to take to protect employees in construction from the hazards associated with exposure to respirable crystalline silica.

Download on the ADSC website at www.adsc-iafd.com/resources
with Thornton Tomasetti, and McHugh Construction, HBI developed a micropile solution that addresses both concerns—lack of lateral bracing as well as lack of ability to return water to the surface—by installing an oversized casing 10-ft into the lake bottom. The key to this installation is the relatively light drill rig, less than 30 tons, that is used for installing the micropiles. The existing precast concrete decking for the pier can carry the loads of these smaller rigs. This approach provided a significant savings to the project owner.

Historically, drilled shafts have earned their prominent place in the Chicago construction market and that will not substantially change going forward. But the micropile work done to date on the Navy Pier shows that these slender foundation elements are forging their own place, particularly where access is challenging, sites are restricted, or large heavy drill rigs cannot be accommodated.

More than 100 years after initial construction, Navy Pier has evolved into a major tourist attraction.