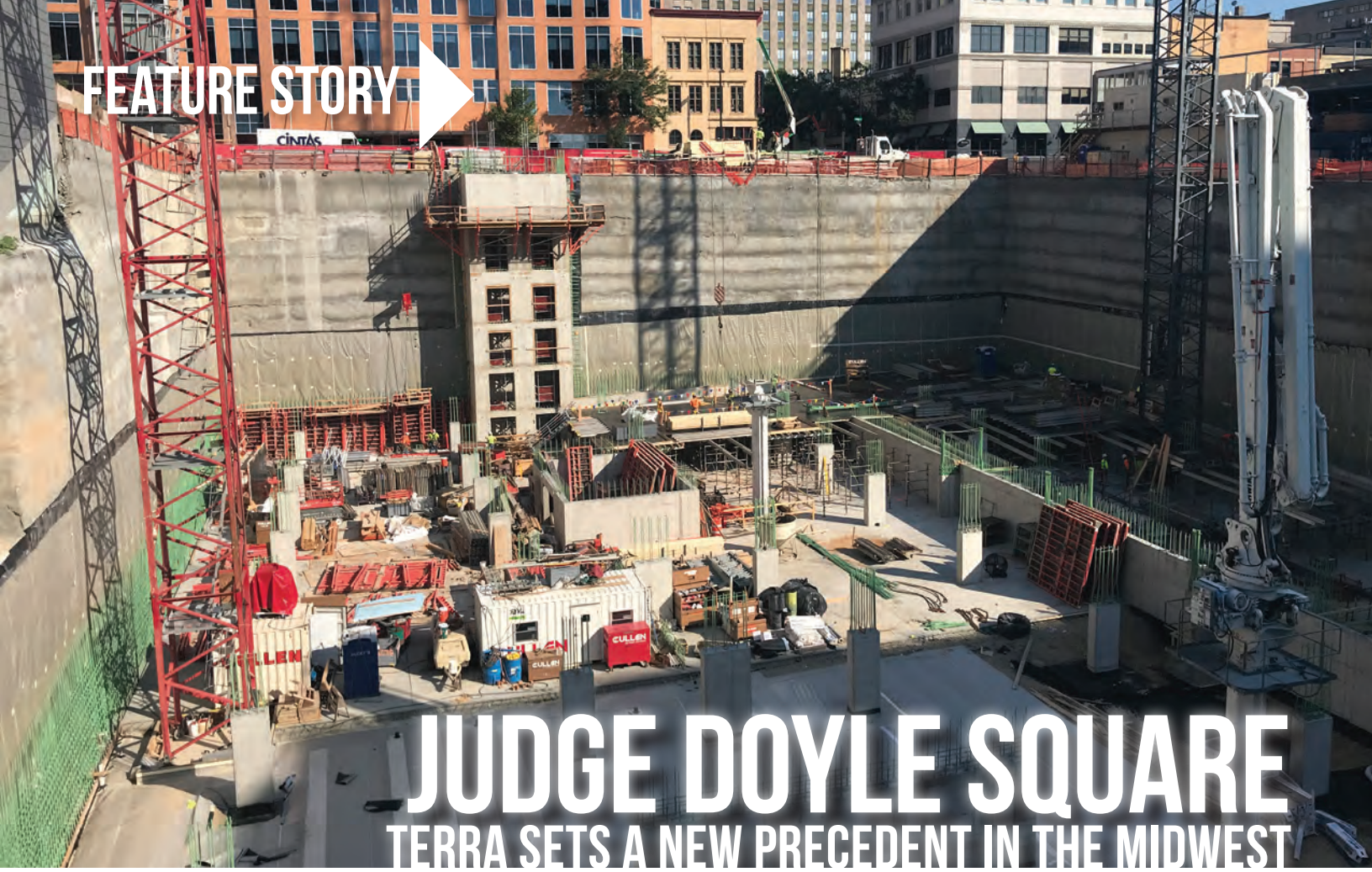

JUDGE DOYLE SQUARE

TERRA SETS A NEW PRECEDENT IN THE MIDWEST

BY ERIC BAHNER, P.E., D.GE., CHIEF ENGINEER/ESTIMATOR AND JASON PIETON, PROJECT MANAGER, TERRA

The Judge Doyle Square project is located one block from the Capital Square in downtown Madison, Wisconsin. The project consists of three structures that will house a hotel, office, retail space, apartments, plus an above- and below-ground parking structure. Terra Engineering and Construction Company (Terra) was chosen by the general contractor, J.P. Cullen, to design and install the earth retention system for the parking structure. The 70-foot deep soil nailed excavation is the deepest in the Madison area, and believed to be one of the deeper soil nailed excavations in the country. Terra's 40 years of experience in designing and installing similar systems, combined with extensive experience with the geology and subsurface conditions in the Madison area, made Terra ideally suited for this project.

GEOLOGY AND SUBSURFACE CONDITIONS

The subsurface conditions on this project are typical of the glacial tills found in the Capitol Hill area of Madison, Wisconsin. The conditions across the site are uniform and consist of medium dense to very dense silty sand with moderate to significant gravel content and scattered cobbles and boulders. Soils with standard penetration resistances (N-Values on the boring logs) greater than 50 blows/foot were present at ten feet below existing grade and reached as high as 50 blows/three inches at about 20 feet below grade. Monitoring wells indicated that groundwater would be present at a depth of 30 feet on this site.

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The footing elevations were as much as 40 feet below groundwater level measured in the monitoring wells. Additionally, perched water in cleaner sand and gravel layers was encountered above the static water level and needed to be drained as the excavation was advanced. While the dense, silty soils do not give up much water, the dewatering system was an important component of the excavation and earth retention system installation, especially given the unusually high amount rainfall through spring, summer and fall of 2018.

DESIGN

The site is in a dense, downtown urban environment with adjacent city streets, buildings and numerous known and unknown underground utilities. Our design had to accommodate surcharge loads of an existing four-story parking garage, existing two-story historical building, as well as typical construction surcharges. There were several earth retention options considered, but the final verdict in this case was soil nailing. The system, as designed, called for 135,000 lineal feet of soil nails, 800 cubic yards of grout, and 1,400 yards of shotcrete.

Madison is one of only two major U.S. cities built on an isthmus. Lake Monona, which holds 28 billion gallons of water is located less than 500 feet to the southeast of the project site. Lake Mendota, which holds 130 billion gallons of water, is located less than 3,000 feet to the northwest. Experience has shown that groundwater levels on the isthmus tend to follow the local topography, even to elevations much higher than the local lake levels. Experienced professional engineers can testify to the impact that hydrostatic pressures have on an earth retention system, so accounting for it was a key component of our design. We installed geocomposite drain board every five feet horizontally behind the shotcrete face for the full excavation depth. This drain board was designed to allow an uninterrupted path for water discharge, eliminating the potential for hydrostatic pressure build-up behind the shotcrete face. We also developed plans to install a gravity drain scheme to dewater at the excavation face in advance of excavation and soil nail installation. Fortunately, we never had to use it.

When it comes to space on an urban construction project, every square inch is important and expensive. The soil nail wall served as the back side form of the foundation walls for the new parking structure, so wall alignment was critical to minimizing encroachment into the wall footprint. If the wall was either out of plumb or offset too far away from the foundation wall, the cost of the additional concrete would have been significant. Every one inch out

of alignment would have resulted in an additional construction cost of approximately $250,000. To achieve the amount of verticality necessary, a customized mesh had to be fabricated rather than the typical flat mesh panels. The pre-stamped mesh was bent to fit behind the waler bars and anchor plates prior to applying the shotcrete.

Terra also used a third-party survey crew to monitor wall verticality and to measure lateral movement of the wall so that issues could be identified and addressed immediately. Fortunately, no issues arose and when the project was complete, the actual verticality and movement of the wall was much less than contract documents allowed.

Nail testing before and during production is always recommended to confirm design assumptions. Before the work began, we completed several sacrificial ultimate strength tests. Proof tests were completed on 5% of the production nails, and a minimum of several tests per vertical lift. The testing provided peace of mind for the entire project team and allowed the work to continue without delay.

CHALLENGES

The initial construction schedule called for the footings to be poured in April or May 2018, so Terra's work had to start in November 2017, which is typically the start of brutally cold weather in southern Wisconsin. That winter was especially artic-like, with nightly lows reaching as far as -20 degrees. The project team was concerned that the cold temperatures could cause the shotcrete to freeze and lose its structural strength. To prevent this, Terra used

double insulating blankets and heat during the curing process. Temperature sensors were also installed to track the shotcrete temperatures. The sensors showed that we were able to keep temperatures around 50 degrees or higher, allowing the shotcrete to properly cure and develop its structural strength.

While cold weather is expected in Wisconsin, 100-year floods are not. At about the time that the construction team reached the bottom of the 70-foot excavation, the Madison area received two record-setting rain events. The first occurred in the beginning of May 2018 and dropped more than five times the monthly average of rain. By the time the second event was complete in August, the area had encountered rain levels considered to be a 100-year flood event. The rain, coupled with the already significant groundwater issues, made site dewatering especially challenging.

Like most urban environments, numerous utilities were present around the perimeter of the site. Consequently, Terra's design had to account for all the utilities and required that the soil nails be installed at numerous vertical and horizontal angles to avoid conflicts. Where especially steep vertical angles were required, it was necessary to offset subsequent nail rows to avoid conflicts with adjacent nails.

Randomly dispersed throughout the site were large boulders that were in the line of retention system. These boulders not only conflicted with the earth retention system, but the footprint of the building foundation walls, as well. During removal, exceptional care had to be taken to prevent over-break of the boulders because any loss of soil around the boulder could have jeopardized the stability of the earth retention system. This was especially problematic for a system that relied on a shotcrete facing to be applied against the excavation and be within the project-defined horizontal tolerances.

At a depth of approximately 40 feet, the access ramp needed to be removed, which posed additional challenges for the final stages of the excavation. The lack of ramp access meant that shotcrete, grout and other construction materials had to come from 50 to 70 feet above the excavation base. This also meant that once the excavation was complete, construction equipment in the excavation had to be removed by a crane from street grade. The congested site meant that the outriggers of the 550-ton crane, required to do this work, were

located less than 15 feet away from the retention system, and the counterweight of the crane was less than three feet away from a nearby existing building. The loads on the outriggers closest to the retention system were on the order of 200,000 lbs. Given the presence of miscellaneous fill beneath the paved roadway and thawing ground conditions, Terra installed rigid inclusions at the anticipated outrigger locations. The rigid inclusions provided dependable support for the crane so equipment could be safely hoisted and removed from the excavation, as well as performing other necessary functions during the remainder of the project.

ACKNOWLEDGMENTS

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Project Team

Owner
City of Madison, Wisconsin

General Contractor
J.P. Cullen

Earth Retention Contractor
Terra Engineering &
Construction Corporation

Excavation Contractor
Edgerton

Geotechnical Engineer
CGC, Inc.