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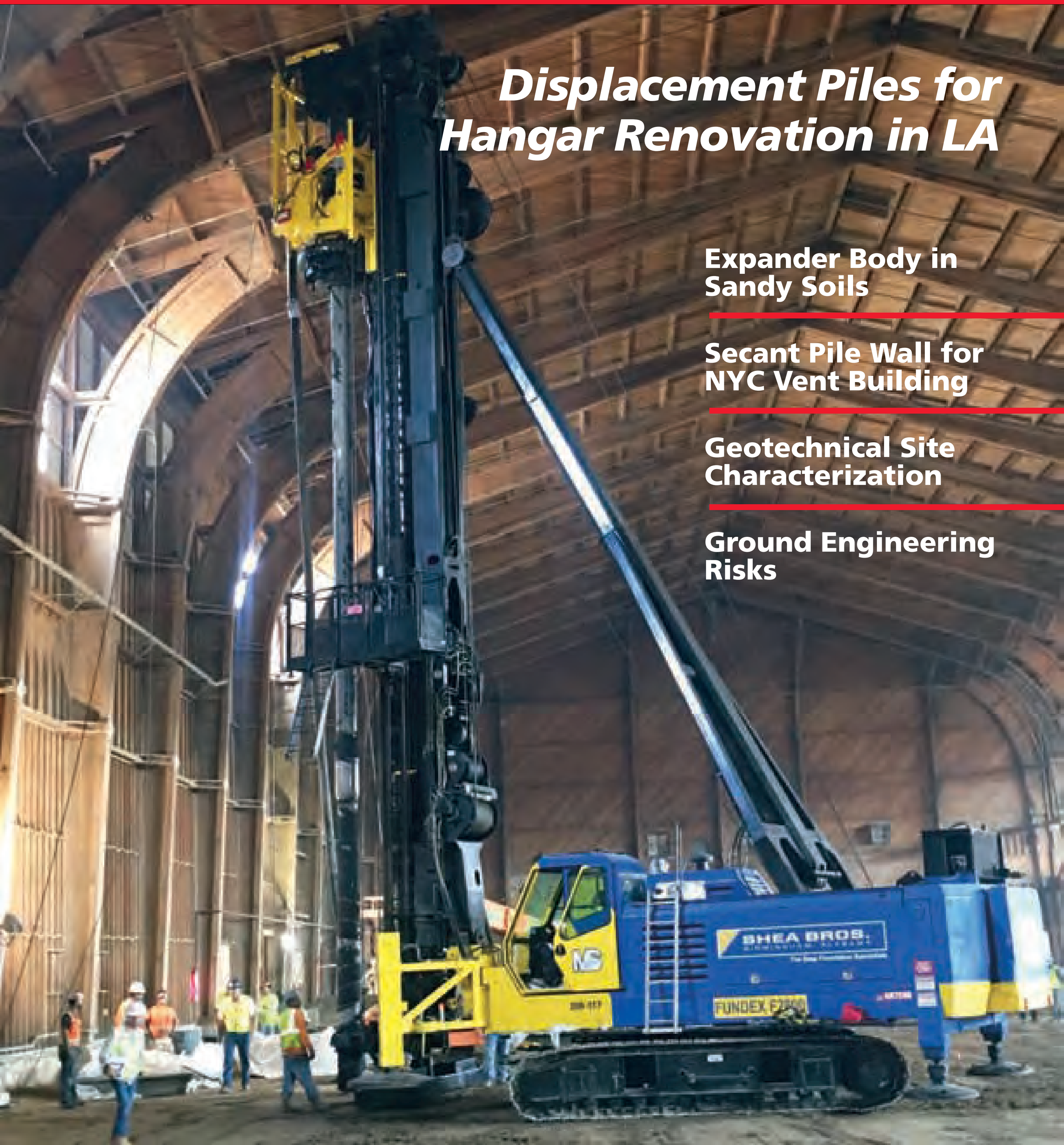
DEEP FOUNDATIONS



Displacement Piles for Hangar Renovation in LA

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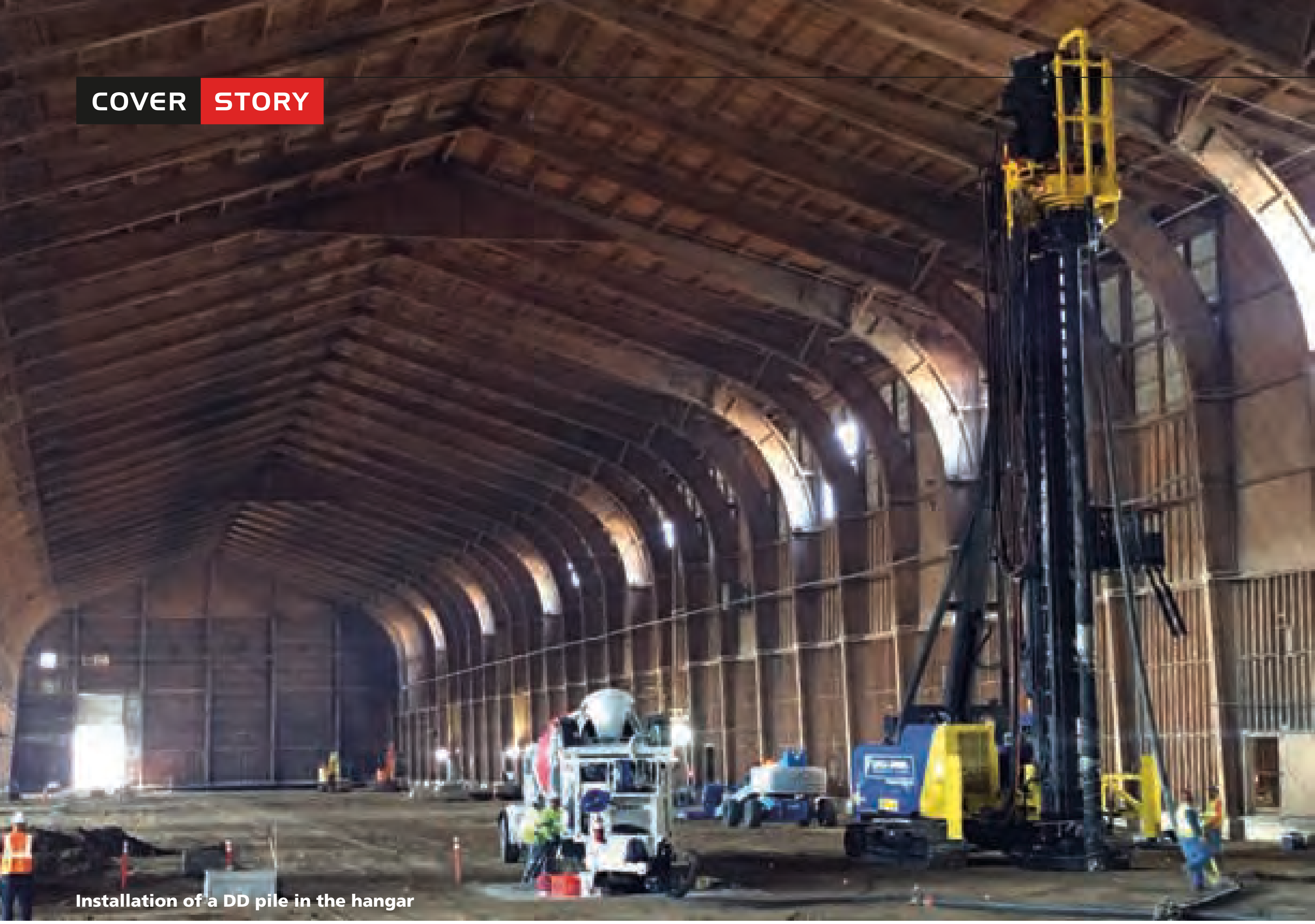

Installation of a DD pile in the hangar

Piles Installed for Southern California Aircraft Hangar Renovation

Morris-Shea has completed the installation of permanently-cased cast-in-drilled hole (PC-CIDH) and DeWaal® drilled displacement (DD) piles at an aircraft hangar renovation jobsite in Playa Vista, Calif. The Morris-Shea team worked closely with the general contractor, MATT Construction, on the foundation development for this WW2 era building and landmark West Los Angeles structure. Many of the site's existing buildings are nationally registered historic landmarks. To accommodate the jobsite's restricted access and unique environmental concerns, the project engineer specified PC-CIDH and DD piles for the massive structure's new foundation.

Exterior of hangar

The installation of DeWaal piles utilizes a different method of concrete placement than other DD pile methods in use. The uniqueness of this system entails using a self-consolidating, coarse aggregate concrete that is placed via a large-diameter tremie pipe and temporary casing. Other DD pile methods use a closed pump system and grout or concrete, similar to an augercast pile.

More than 1,000 DD piles and over 400 PC-CIDH piles were installed in critical areas of the old aircraft facility. Project phases in 2017 included the installation of deep foundations under the larger portion of the 319,000 sq ft (29,636 sq m) complex to accommodate the load capacities required for new and renovated structural development. For the 2018 phase, the contractor's compact Fundex CD20 drill rig was maneuvered inside the building's interior to install 217 PC-CIDH piles that are 14 in (355 mm) in diameter. This quiet vibration-free application was well suited for the unique urban jobsite with its surrounding technology facilities.

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To provide load transfer, the DD piles installed in earlier phases of the project incorporated a full-length reinforcing center bar and a partial length steel cage within the concrete, rather than a permanent casing. Similar to the PC-CIDH piles, the DD pile system is a vibration-free application that offers the high lateral capacities required to meet this region's seismic concerns and to accommodate the unique subsurface soil conditions.

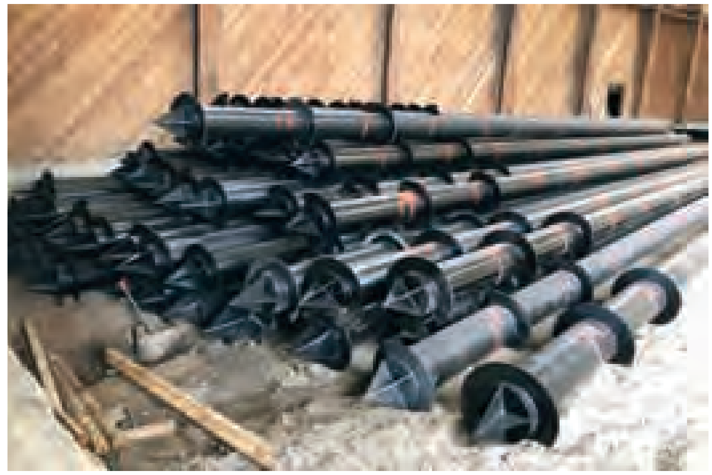
Pile Specification Process

Prior to commencing the project, Morris-Shea proposed to the general contractor that DD piles and PC-CIDH piles be accepted for use on the project. It was agreed that these foundation systems were uniquely qualified for this project. DD and PC-CIDH piles provided foundation options that met all engineering requirements while providing safety, schedule, environmental and engineering performance benefits.

The DD piles were used primarily where vertical and horizontal clearances were sufficient for rig access and the application of this system. PC-CIDH piles were installed where the restricted access or interior height clearances were problematic for the DD piling rigs. Project considerations included the presence of contaminated soils within the building complex resulting from the site's previous use as an airplane hangar. The primary concern was that contaminated groundwater perched atop the upper aquifer (Bellflower Aquitard) not be allowed to develop a mechanism to cross-contaminate or pollute the lower aquifer (Ballona Aquifer).

Constructed pile cap atop PC-CIDH piles

Based on the installation methodologies involved in installing the DD and PC-CIDH piles, it was determined that their use at this site was appropriate and no significant potential existed for contamination from pile installation. DD piles are commonly used in existing petrochemical facilities where the presence of environmentally contaminated soils and groundwater require the installation of deep foundation support without cross-contaminating deeper soils or aquifers. In addition, the densification of the soil around a DD pile helped to prevent groundwater from migrating along the pile, further eliminating the risks relating to cross-contamination of the aquifer.



PC-CIDH steel casings with fabricated pile points

DD Pile Installation

Installation of a DD pile began with the advancement of the drilling tool fitted with a disposable end plate. The tool was advanced using significant axial crowd and rotational torque until the drilling criteria was achieved. During drilling, the sidewall of the borehole was supported by a temporary casing that also acted as a drill stem and large-diameter concrete tremie pipe. Upon reaching the specified depth, the advancement of the drill tooling was stopped, and a full-length reinforcing center bar was placed within the temporary casing/drill stem.

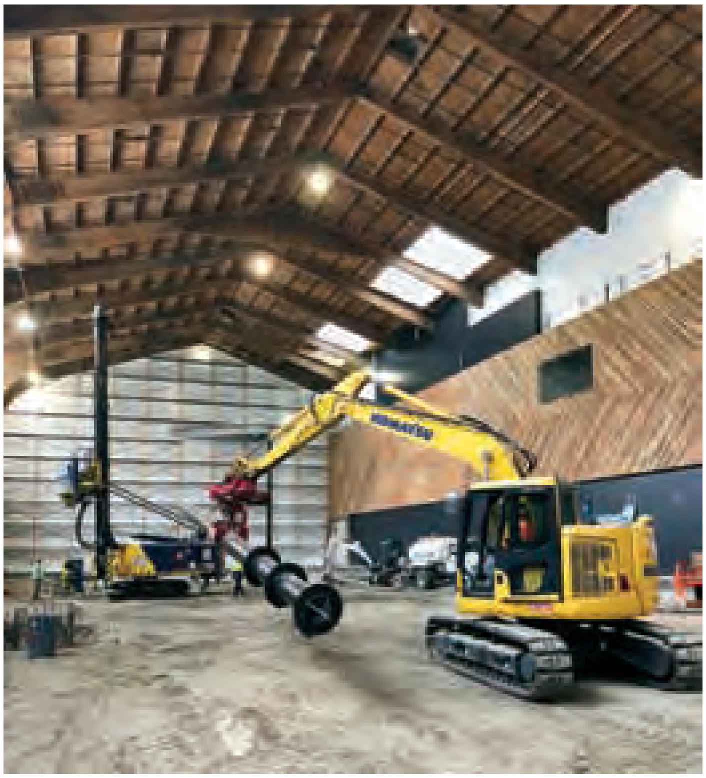
High slump, self-consolidating concrete with coarse aggregate was pumped through the temporary casing functioning as a tremie pipe. While pressurized concrete flowed into the ground, the drilling tool was withdrawn and the sacrificial endplate was left behind, where it remained in direct contact with the soil. The reverse flights, located on the upper portion of the displacement element, assisted with the extraction by cutting and recompacting any loose soil. This added soil densification helped to minimize concrete overconsumption and ensured the piles were constructed without risk of reduction in pile cross-section. During the withdrawal of the tool, the concrete head within the drill stem/tremie pipe was maintained at all times at an elevation higher than the ground level, allowing the construction of a monolithic concrete column in the ground.

After withdrawal of the tooling, a steel reinforcing cage was placed in the pile using centering devices to maintain proper coverage and alignment. These DD piles at the jobsite were installed using two Fundex F2800 drill rigs equipped with special leaders that were made to accommodate the 57 ft (17.4 m) height restriction. The 325,600 ft-lb (45 tonne-m) rotaries were fitted with special tube clamps to maximize the drilling depth within the limited headroom. Individual DD piles were installed with cycle times as low as 10 to 15 minutes.

Upon completion of each pile, the rig automatically transmitted the installation data to project managers and quality control professionals. To aid in this process, Morris-Shea pile capacity software referenced load test data from piling jobs dating back to 1992 to accurately predict pile behavior.

PC-CIDH Pile Installation

PC-CIDH piles were ideal for use where restricted access conditions and low quantities of piles were present. The soil conditions consisted of loose to medium-dense soils above a dense sand and gravel layer to a depth of about 40 ft (12 m) below the ground surface. Similar to the DD piles, the installation of the PC-CIDH piles displaced and densified a zone of soil around the casing, preventing groundwater from migrating alongside the pile and eliminated risk of cross-contamination of the aquifer.



Handling and positioning PC-CIDH casing

The PC-CIDH piles were installed using a Fundex CD20 drill rig, which advanced the steel casings into the ground by simultaneously applying up to 144,710 ft-lb (20 tonne-m) of torque and 33,070 lb (15 tonne) of crowd force. Minimal to no drilling spoils were produced or transported to the working surface, which was a key benefit of using this technique for this environmentally-sensitive project. After installation, each steel casing was then filled with self-consolidating concrete and reinforcing steel, producing the required high load bearing capacity. The structural design of the piles took advantage of the fact that casings remained in the ground, which increased lateral support and eliminated the need for steel reinforcing cages. Center reinforcing bars were added to provide tension connection to the pile caps and to improve seismic performance.

Construction of this piling system consisted of advancing a steel casing with a wall thickness of about ¼ in (6 mm) and a fabricated pile point and helical steel flight into the ground using both rotary torque and crowd force. As the pile advanced into the ground, the soil around the casing was displaced laterally. This application process continued until the desired depth was achieved. The low vertical clearance within the structure's interior required that sections of the steel casing as short as 10 ft (3.05 m) be welded together to achieve the required penetration into the bearing layer.

Each casing was coated to provide corrosion protection and to mitigate potential groundwater seepage along the pipe-soil interface. The coating was chemical and abrasion resistant and did not significantly impact the capacity of the pile. All test piles used the same coating, thereby facilitating the development of installation criteria for the coated pipe. Static load testing and structural calculations were performed by Morris-Shea and were submitted to verify the geotechnical and structural performance of both piling systems. All aspects of the drilling process and concrete placement were observed and recorded by Morris-Shea automated monitoring equipment (AME) in addition to third-party inspectors from the project geotechnical engineer, Group Delta Consultants (GDC).

Pile Load Testing

A pile load testing program was performed to evaluate axial compressive capacity and pile installation criteria for a 14 in (356 mm) diameter DD pile and a 14 in (356 mm) PC-CIDH pile. GDC prepared a Comprehensive Geotechnical Report (November 5, 2015) and an Addendum (March 18, 2016). The report and addendum provided geotechnical design recommendations for site development and foundation support for the project.

The project geotechnical report described a variable dense sand bearing layer across the site, where the top of the bearing layer ranged between El. -25 ft (El. -7.6 m) to El. -34 ft (El. -10.4 m). Morris-Shea hired local subcontractor, Kehoe Testing, to perform Cone Penetration Tests (CPTs) at this site. According to the City of Los Angeles standards, the number of required CPTs is one CPT per every 10,000 sq ft (930 sq m) of building footprint or a ratio of CPTs to the quantity of total production piles installed. CPTs were performed at each of the four test pile locations in addition to at 24 other locations prior to the pile load testing program.

Based on the relatively consistent subsurface stratigraphy across the site, the number of DD pile load tests performed on adjacent projects, existing site accessibility, and the successful experience on other DD pile projects in the area, a total of four DD piles and two PC-CIDH piles were tested at locations along the exterior close to Buildings 14, 15 and 16. Morris-Shea installed the test and reaction piles and performed the axial static load tests.

Installing PC-CIDH pile in tight space near exterior wall

GDC observed the piling installation, oversaw the low strain dynamic pile integrity testing and observed and monitored the load testing program in accordance with ASTM procedures. Morris-Shea exhumed a test pile after completion of the testing for physical examination of the actual condition. GDC reviewed and evaluated the load test data and provided recommendations for allowable axial pile capacities, pile lengths and installation criteria for both piling systems. (Note: the project testing and recommendations information from Group Delta Consultants was acquired from a publicly available source.)

Welding additional casing length on PC-CIDH pile

Monitoring of Test Pile Installation

The test piles were intended to penetrate a minimum of 3 pile diameters into the dense sand bearing layer, but no less than at least 6 in (150 mm), with tip elevations between El. -25 ft and -34 ft (El. -7.6 m and -10.4 m). Prior to pile installation, the location of the bearing layer was estimated based on the CPT data. The penetration into the bearing layer was identified during installation by measuring torque from the rig and documenting the installation criteria of a continuous minimum torque of 60,000 ft-lb (81.3 kN-m) for at least 3 pile diameters into the sand bearing layer.

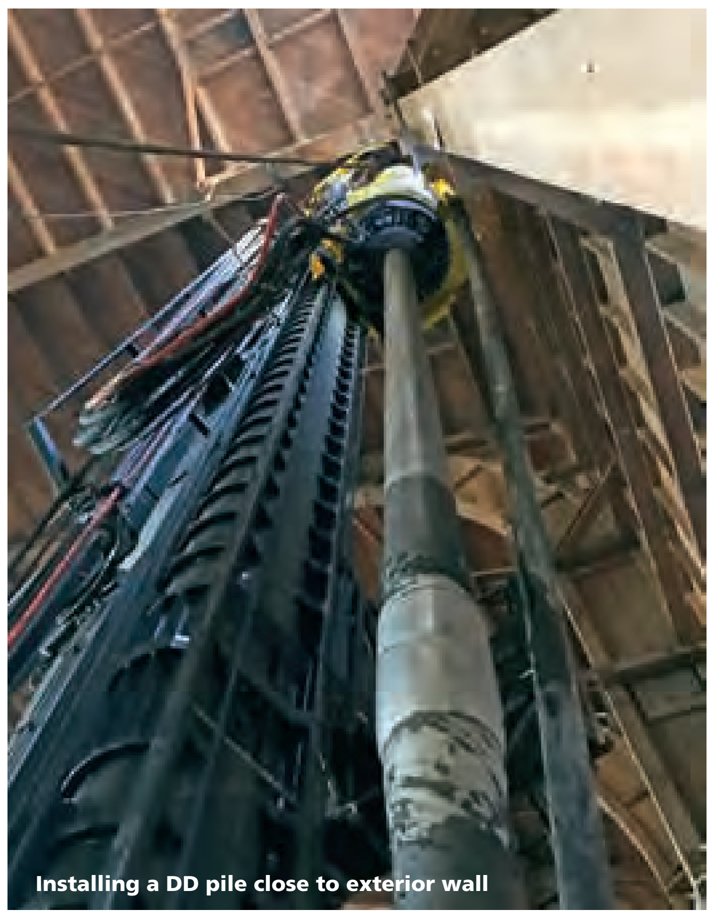
During installation of the DD piles, the drill rig instrumentation recorded depth, pumped concrete volume, volume ratio, pump strokes, head pressure and elapsed time. The DD piles were advanced to practical refusal, which was defined as a penetration rate of 5 minutes of drilling for a penetration of 12 in (305 mm) or less at a minimum rotary torque of 60,000 ft-lb (81.3 kN-m) or 3.5 ft (1.07 m) embedment into the dense sand layer, whichever occurred first. GDC observed concrete placement to verify that no excess bleeding occurred at the pile head during installation. Uniaxial compression testing was performed on concrete cylinder samples, which indicated a minimum 28-day compressive strength in excess of 5,000 psi (34.5 MPa) was attained for each of the tested samples.

The PC-CIDH test piles penetrated about 6 in (152 mm) and 9 in (229 mm) into the dense sand bearing layer, to tip elevations at El. -26.5 ft (El. -8.08 m) and El. -26.8 ft (El. -8.17 m). The penetration into the bearing layer was identified during installation by monitoring the penetration rate of the pile. The pile installation was terminated when the penetration rate slowed to a rate of 5 minutes of drilling for a penetration of 12 in (305 mm) or less at a minimum rotary torque of 60,000 ft-lb (81.3 kN-m).

The DD test piles were statically loaded to a maximum of 600 kips (2670 kN) of axial compression load. The test results demonstrated that the piles provided more than the required factor of safety for the allowable capacity of 200 kip (890 kN) of working load. The PC-CIDH piles were loaded to a maximum of 370 kips (1646 kN) of axial compression load and easily demonstrated an adequate factor of safety for the 100 kip (445 kN) working load. Results from the nondestructive testing indicated sound pile integrity after installation. Based on the test results and for a working level at about El. +16 ft (El. +4.9 m), the lengths of production piles ranged from approximately 42 to 50 ft (12.8 to 15.2 m).

Conclusion

Morris-Shea installed more than 1,000 DeWaal piles and more than 400 PC-CIDH piles in critical areas of this old aircraft facility, and worked closely with MATT Construction and Group Delta Consultants to develop an efficient and comprehensive geotechnical plan for renovating the hangar foundation. This successful team approach brought the project to completion two weeks ahead of schedule.



Installing a DD pile close to exterior wall

Gordon King is an engineer manager with Morris-Shea. He received a B.S. degree from the University of Dundee, Scotland, an M.S. degree in geotechnical engineering from the University of Durham, England, and has more than 30 years of geotechnical consulting and specialist foundation contracting experience. King is currently a member of the DFI Augered Cast-In-Place Pile Committee. King worked with Michael Spano of Ninetimes, an advertising and design firm, on writing this article.