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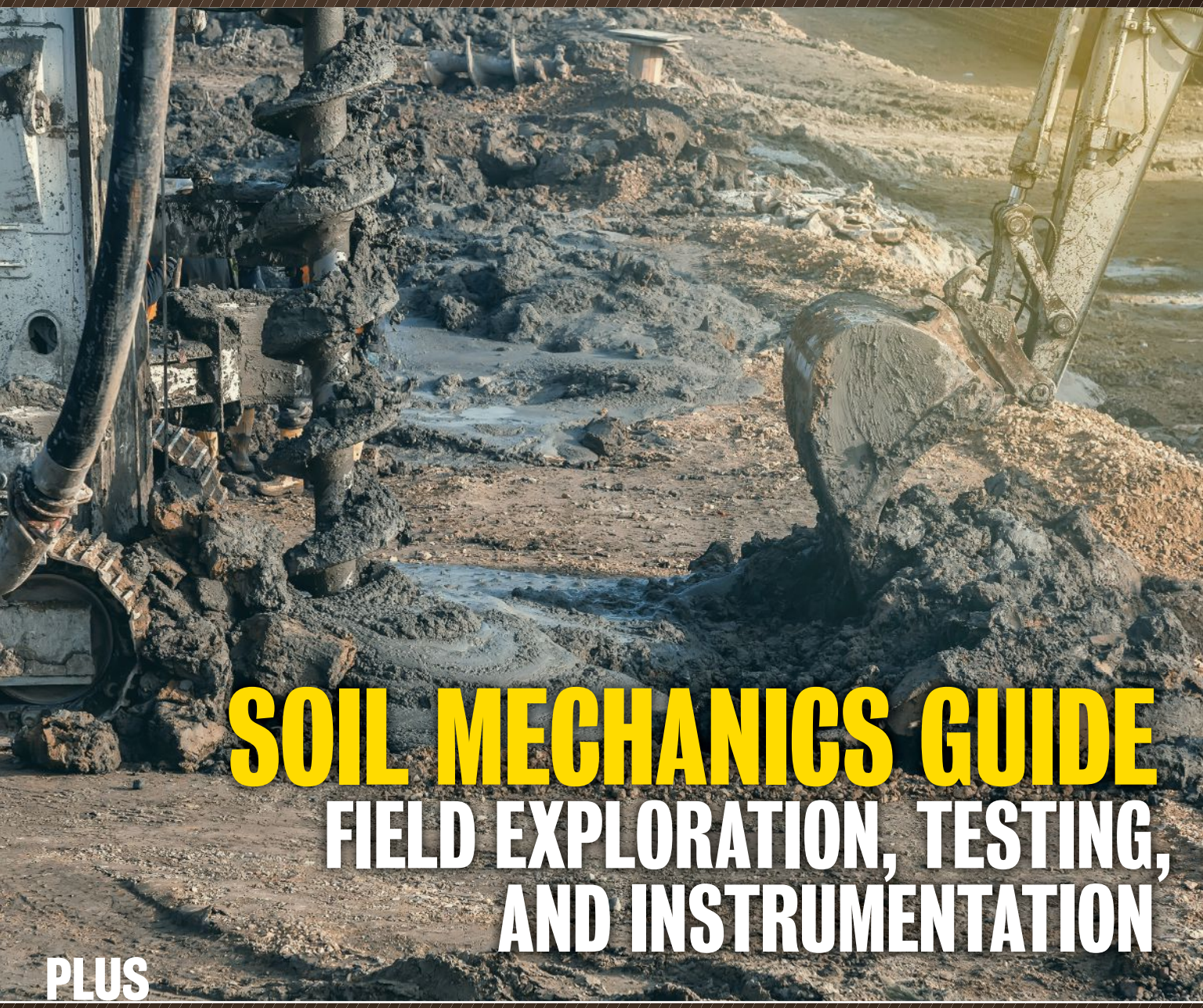

SOIL MECHANICS GUIDE

FIELD EXPLORATION, TESTING, AND INSTRUMENTATION

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FOUNDATION ENGINEERING
Dusseldorf's Tallest Residential Tower

DUCTILE IRON PILES
Solve Industrial Retrofit Challenges

THERMAL INTEGRITY PROFILING
Developed by Pile Dynamics, Inc.

By Brendan Fitzpatrick, P.E. and Gregg Piazza, P.E.

DUCTILE IRON PILES SOLVE INDUSTRIAL RETROFIT CHALLENGES

New Jersey, USA

Industrial warehouses, distribution centers, manufacturing and shipping facilities are making way for new technology, economic and business needs with new construction or renovations to existing facilities. The vision for these facilities is to provide optimal space and functionality with the construction process often yielding to unique geotechnical challenges and solutions. As various industry needs evolve, so do the requirements for facility expansion, growth and improvement. Ductile Iron Piles, distributed by DuroTerra, LLC and manufactured by Austrian-based Tiroler Rohre GmbH, have provided solutions for many of these evolving facilities.

Development of industrial facilities is certainly evident along the New Jersey turnpike. A 600,000 square foot beverage distribution facility for American Beverage Packers, LLC in Edison, New Jersey was planned on a site containing undocumented fills (sand, clay, silt and debris) underlain by a medium dense to very dense native sand locally known as the Magothy Raritan Formation. Early site work on the project included ground improvement to reinforce the undocumented fill. The system was designed and installed by GeoStructures, Inc. to depths of 10 to 15 feet to support shallow foundations and slab-on-grade construction.

When the warehouse superstructure was completed and interior build-out was in progress, the ARCO Design/Build Industrial project team identified additional facility improvements required to address future usage requirements. The improvements included the construction of an approximately 36,000 square foot steel frame mezzanine located along the west side of the building interior. Retrofit for the new mezzanine level included construction of a new cast-in-place concrete wall and 40 column footings interspersed among existing walls, column footings, areas of thickened slab and underground utilities. The new column loads ranged from 100 to 300 kips and wall loads were between 7 and 8 kips/foot. Aligned along an existing column line, the pile supported grade beam for the new wall had to leap frog fifteen existing column footings and intersect eight thickened slab areas.

The project team quickly recognized that the ground improvement strategy applied to the original building foundations was no longer practical for support of the new foundations since the facility now had overhead clearance restrictions of 40 to 50 feet. GeoStructures

Interior installation of Ductile Iron Piles.

considered a variety of piling options and arrived at the solution consisting of Ductile Iron Piles. GeoStructures had previously used Ductile Iron Piles on a mezzanine in a large international shipping facility near Philadelphia International Airport. The Philadelphia shipping facility installation included over 300 piles driven to depths ranging from 70 to over 100 feet in a 30-ft headroom application.

Ductile Iron Piles, manufactured by Austrian-based Tiroler Rohre GmbH, are a low vibration, modular driven pile system. The pile sections are manufactured in 5 meter (16.4 ft) lengths that feature a unique Plug-and-Drive (bell and spigot) connection. The Plug-and-Drive system forms a rapid, moment-resisting connection when driven using a high-frequency percussion (demolition-type) hammer mounted on a medium-sized excavator. The combination of the connection and high-frequency energy enables the piles to be driven efficiently to considerable depths while also generating minimal vibrations compared with traditional driven pile operations. The modular nature of the system and relatively small installation equipment makes it well-suited for constrained urban sites or interior renovation work where overhead clearances are typically 18 feet or higher.

While the system has been used cost-effectively on wide-open sites, the majority of projects include building additions, interior retrofit work or tight, urban development sites. Ductile

DUCTILE IRON PILES, MANUFACTURED BY AUSTRIAN-BASED TIROLER ROHRE GMBH, ARE A LOW VIBRATION, MODULAR DRIVEN PILE SYSTEM. THE PILE SECTIONS ARE MANUFACTURED IN 5 METER (16.4 FT) LENGTHS THAT FEATURE A UNIQUE PLUG-AND-DRIVE (BELL AND SPIGOT) CONNECTION. THE PLUG-AND-DRIVE SYSTEM FORMS A RAPID, MOMENT-RESISTING CONNECTION WHEN DRIVEN USING A HIGH-FREQUENCY PERCUSSION (DEMOLITION-TYPE) HAMMER MOUNTED ON A MEDIUM-SIZED EXCAVATOR.

Project Type: An International Shipping Facility
Project Needs: Cost effective deep foundation
Challenges:
- Overhead height restrictions
- Low vibration requirement
- Tight site access

Solution: End-Bearing Ductile Iron Piles

DUROTERRA™

DUCTILE *IRON PILES*

MODULAR, FAST AND LOW-VIBRATION DRIVEN PILES

A proven, cost-effective pile solution to support foundation loads in problematic soil conditions.

SOLUTIONS FOR:

- Limited overhead clearance
- Constrained work sites
- Low vibration requirements
- Variable ground conditions

BENEFITS:

- Rapid installation reduces project schedules
- Typical cost savings of 20-40%
- Alternative to drilled micropiles, helical piles and other systems
- Addresses variable bearing depths and reduces waste with Plug & Drive connection
- Proven experience for over 30 years

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FOR MORE INFORMATION OR PROJECT FEASIBILITY EVALUATIONS

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PDA testing during Ductile Iron Pile test program.

Iron Piles are manufactured in various sizes (diameter and wall thicknesses) to develop capacities ranging from 25 tons to more than 100 tons in either end-bearing on a competent bearing layer (i.e. rock or very dense ground) or by using an oversized pile shoe and continuously pumping grout during driving to create an efficient grout-to-ground bond zone for frictional capacity similar to a micropile.

The project team reached out to DuroTerra, LLC - American distributor of TRM's Ductile Iron Piles, to discuss the project and for assistance with a feasibility assessment. Multiple challenges confronted the team to complete the additional foundation scope of work. For instance, the selected deep foundation system needed to be installed with low headroom equipment, generate minimal vibration and no spoils, and work around underground utilities and amongst other construction trades and active operations. The project team working with DuroTerra concluded that the Ductile Iron Pile system checked the box for all of the requirements.

Construction required controlled saw-cutting of the existing slab at new wall and pile cap locations, excavation of soil to a depth of 4 feet below the existing slab, selective abandonment and relocation of existing utilities and installation of the piles to achieve the design working capacity. ARCO Design/Build Industrial retained the GeoStructures design/build team to perform the Ductile Iron Pile installation.

Although friction Ductile Iron Piles installed with an oversized cap and continuous grouting operation would yield higher capacities by bonding in the sand, the team was concerned about logistics of grouting during installation within the new facility. Instead, designers proposed a solution using end-bearing Ductile Iron Piles driven

THE PROJECT TEAM REACHED OUT TO DUROTERRA, LLC - AMERICAN DISTRIBUTOR OF TRM'S DUCTILE IRON PILES, TO DISCUSS THE PROJECT AND FOR ASSISTANCE WITH A FEASIBILITY ASSESSMENT. MULTIPLE CHALLENGES CONFRONTED THE TEAM TO COMPLETE THE ADDITIONAL FOUNDATION SCOPE OF WORK.

into the sands to develop capacity. Series 170/9.0 (170 mm outer diameter with 9 mm wall thickness) Ductile Iron Piles with a working capacity of 30 tons were selected.

The pile capacity was controlled by the geotechnical end-bearing resistance in the dense silty sand layer underlying the fill. A full-scale static load test (ASTM D-1143) was performed to 200% of the design load to confirm the capacity. Prior to the start of production, a 32-ft long test pile was installed along the exterior side of the west building wall opposite the new mezzanine area. Test results showed a deflection of only 0.11 inches at loads of 120 kips — twice the design load. Further, the response was linear with nearly completely elastic rebound and suggested much greater capacity out of the pile as installed.

In addition to the full-scale load test, GeoStructures and DuroTerra collaborated on a program to load test several piles utilizing a Pile Driving Analyzer (PDA) to correlate the capacity measured through the PDA with the static load test results. PDA testing was performed by GRL Engineers, Inc. using the high frequency, low energy breaker hammer used to install the piles as well as their Apple drop-weight system to deliver energy to the pile. PDA testing demonstrated an ultimate capacity of 165 kips — exceeding the capacity measured in the full-scale load test. Testing was also performed on 48 ft long piles that confirmed 300 kip ultimate capacity.

Upon successful completion of the load testing, production installation got underway with piles driven through the fill and into the dense silty sand strata to depths 30 to 35 feet. The installed piles were then filled with 2,000 psi neat cement grout and a bearing plate attached to the top of the pile for connection within the pile caps and grade beams. Column support required between two to six piles. In all, 250 piles were installed to support 40 columns and approximately 700 linear feet of new wall. The piles were installed by one crew in about 4 weeks. ■

PDA TESTING DEMONSTRATED AN ULTIMATE CAPACITY OF 165 KIPS – EXCEEDING THE CAPACITY MEASURED IN THE FULL-SCALE LOAD TEST. TESTING WAS ALSO PERFORMED ON 48 FT LONG PILES THAT CONFIRMED 300 KIP ULTIMATE CAPACITY.