THE TRUE COSTS OF OWNING USED **STEEL SHEET PILING**

PUBLISHED 6 TIMES A YEAR

EST. 1984

# PILE BUCK

THE INTERNATIONAL DEEP FOUNDATIONS AND MARINE CONSTRUCTION MAGAZINE

NOV/DEC 2021
VOLUME 37, ISSUE 6

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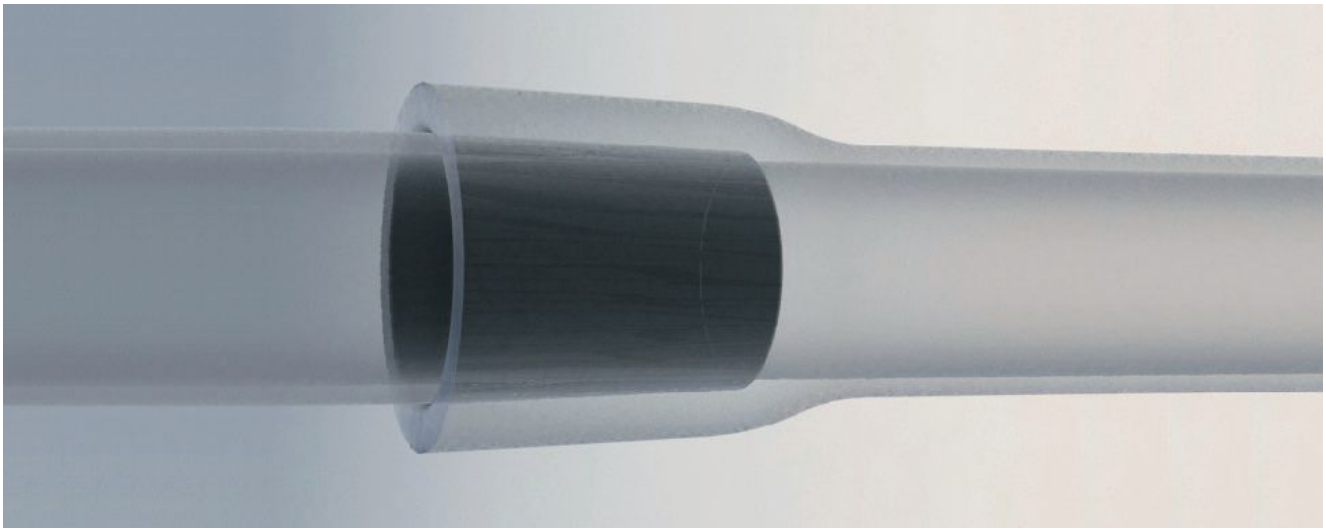
# DUCTILE IRON PILE PRODUCTS FROM DUROTERRA



DUROTERRA™

Ductile Iron Pile Products from DuroTerra
DuroTerra.com
781-817-6053
info@duroterra.com

## DUCTILE IRON PILE PRODUCTS

Ductile Iron Piles (DIPs) are a simple, fast and highly effective modular, low-vibration driven pile system comprised of high-strength ductile cast iron. Pile sections are connected by a proprietary Plug & Drive joint system, eliminating the need for field welding and splicing while providing a high degree of stiffness and full moment capacity. With the use of an excavator fitted with a hydraulic hammer, piles are installed in quick succession leading to fast and easy installation.

Ductile Iron Piles are manufactured by Tiroler Rohre, GmbH of Austria from ductile cast iron, which provides high-impact resistance to the low amplitude, high frequency installation energy. The material also exhibits high ultimate strength, elastic limit and ductility as well as superior corrosion resistance when compared with traditional steel piles.

Ductile Iron Piles are well-suited for supporting loads in a variety of problematic soil conditions including both cohesive and non-cohesive soils and resist compression, tension, and lateral loads.

## PILES & ACCESSORIES: END-BEARING & FRICTION PILES

Ductile Iron Piles have been manufactured by Tiroler Rohre GmbH (TRM) in Austria for over 35 years. Each modular pile section features a Plug & Drive connection consisting of a tapered socket with an internal shoulder for full engagement at one end and a tapered spigot at the other end. This allows the individual pile sections to be connected together to form a pile shaft of virtually any length without the use of special tools. The connection is formed by elastic deformation of the ductile iron and by cold welding of the friction surfaces. This joint exhibits high-compressive strength and superior resistance to bending, such that the rotational stiffness of the joint is greater than the main pile shaft. This connection method eliminates the need for threads, couplers, pins and keys and field welding/splicing on the job site.

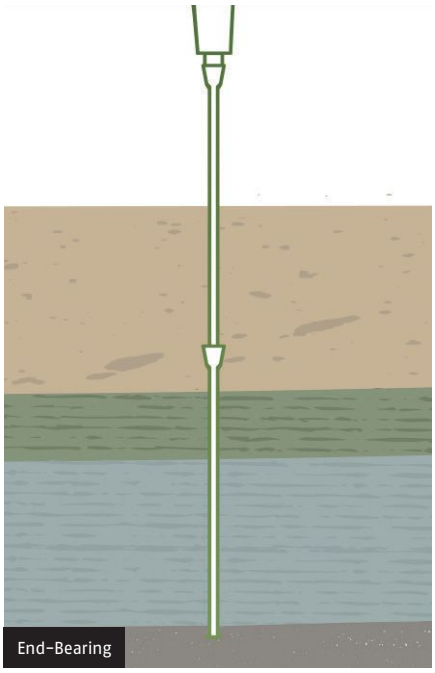
Ductile Iron Pile installation methods consist of either dry (non-grouted during installation) or wet (continuous grouting operation during installation). Additionally, both options can develop load-carrying capacity in either friction in competent soils, end-bearing on very hard ground/rock or a combination of both. The specific pile materials and accessories depend on type of installation and mechanism for load resistance. Both methods utilize a unique combination of installation speed and high capacity that results in a highly cost-effective deep foundation system.

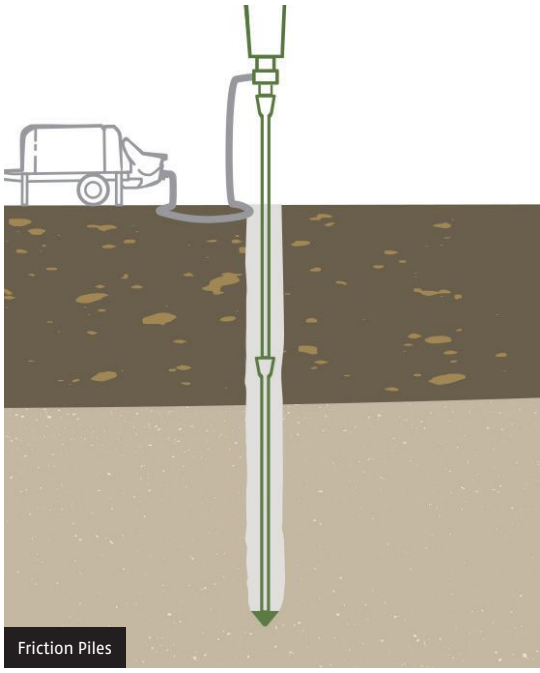
## END-BEARING

Ductile Iron Piles installed for end-bearing are driven through compressible and unsuitable soils to transfer their load to a hard stratum below. They derive their load-carrying capacity at the toe of the pile. End-bearing piles may be installed using a dry installation method (without continuous grouting during installation as pictured) or as wet installation method with oversized pile shoes and continuous pumping of exterior grout, provided "set" is achieved on a competent bearing layer (i.e. rock or glacial till).

## FRICTION PILES

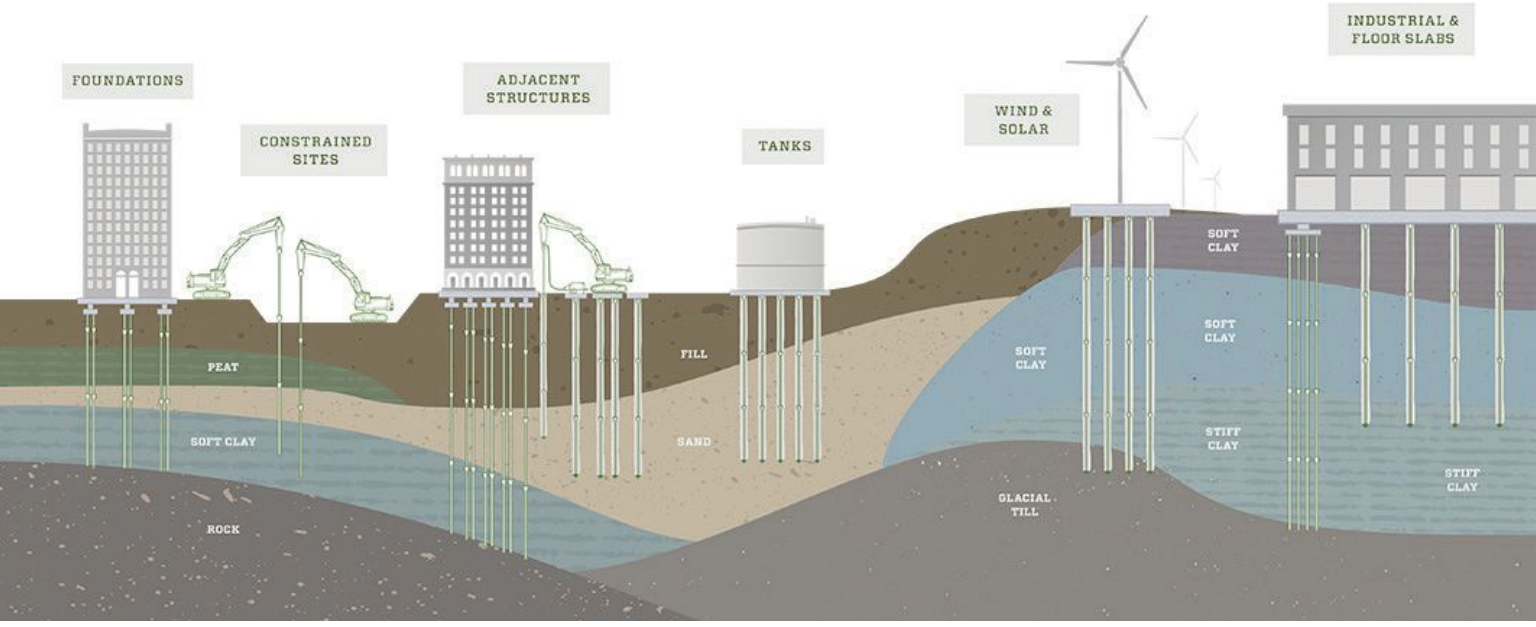
Ductile Iron Piles installed as friction piles penetrate poor soil conditions and develop the majority of the load-carrying capacity in frictional resistance along the perimeter of the pile shaft in the competent strata. While friction piles can use a dry installation method (without continuous grouting) and develop strength through the interface between the soil and the roughened exterior of the ductile iron pile shaft, the majority of friction piles utilize oversized conical drive shoes and exterior grout to encapsulate the pile during driving for very effective grout to ground bonding. The oversized cap results in significant expansion (and densification) of the competent soil while the grout-to-ground bonding provides highly efficient mechanism for load transfer.

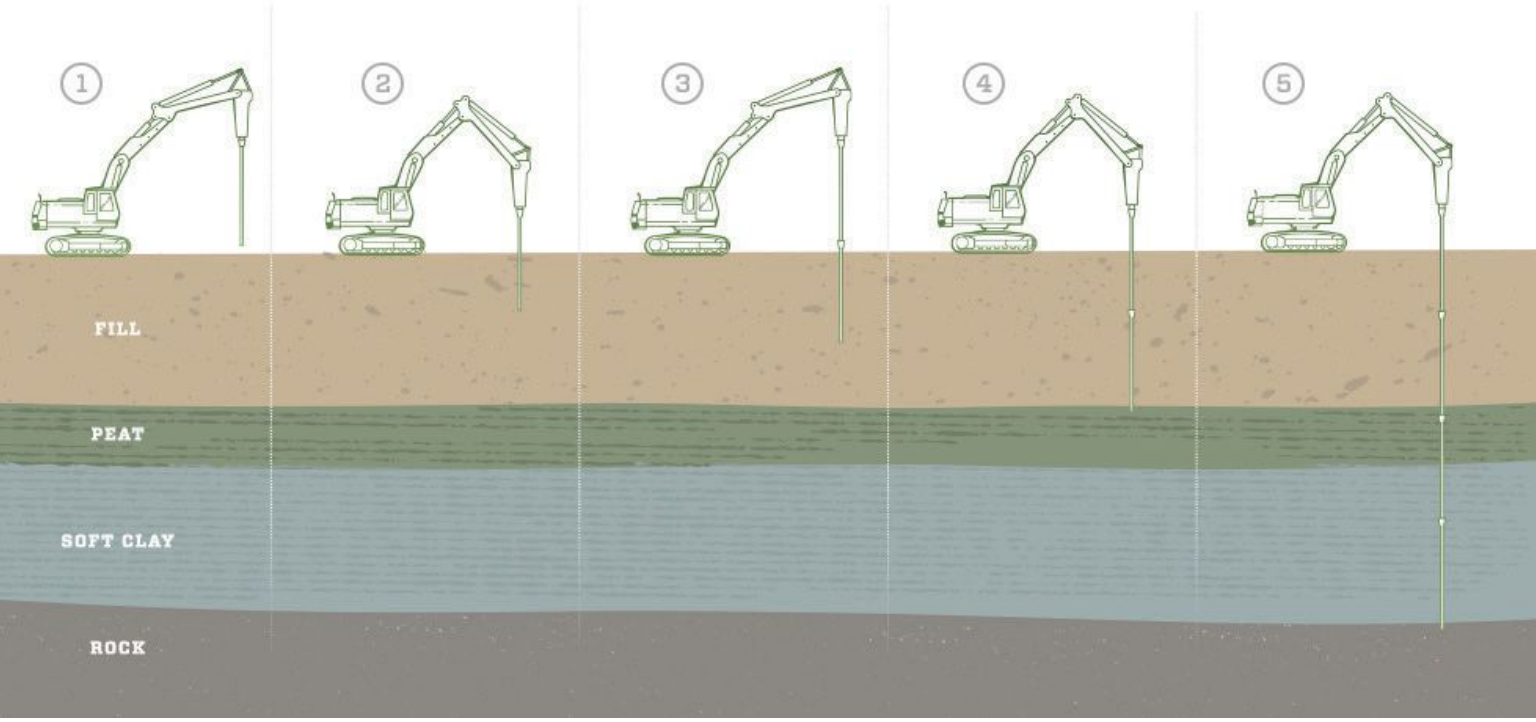

End-Bearing


Friction Piles

## INSTALLATION & EQUIPMENT: HOW DIPS ARE IMPLEMENTED

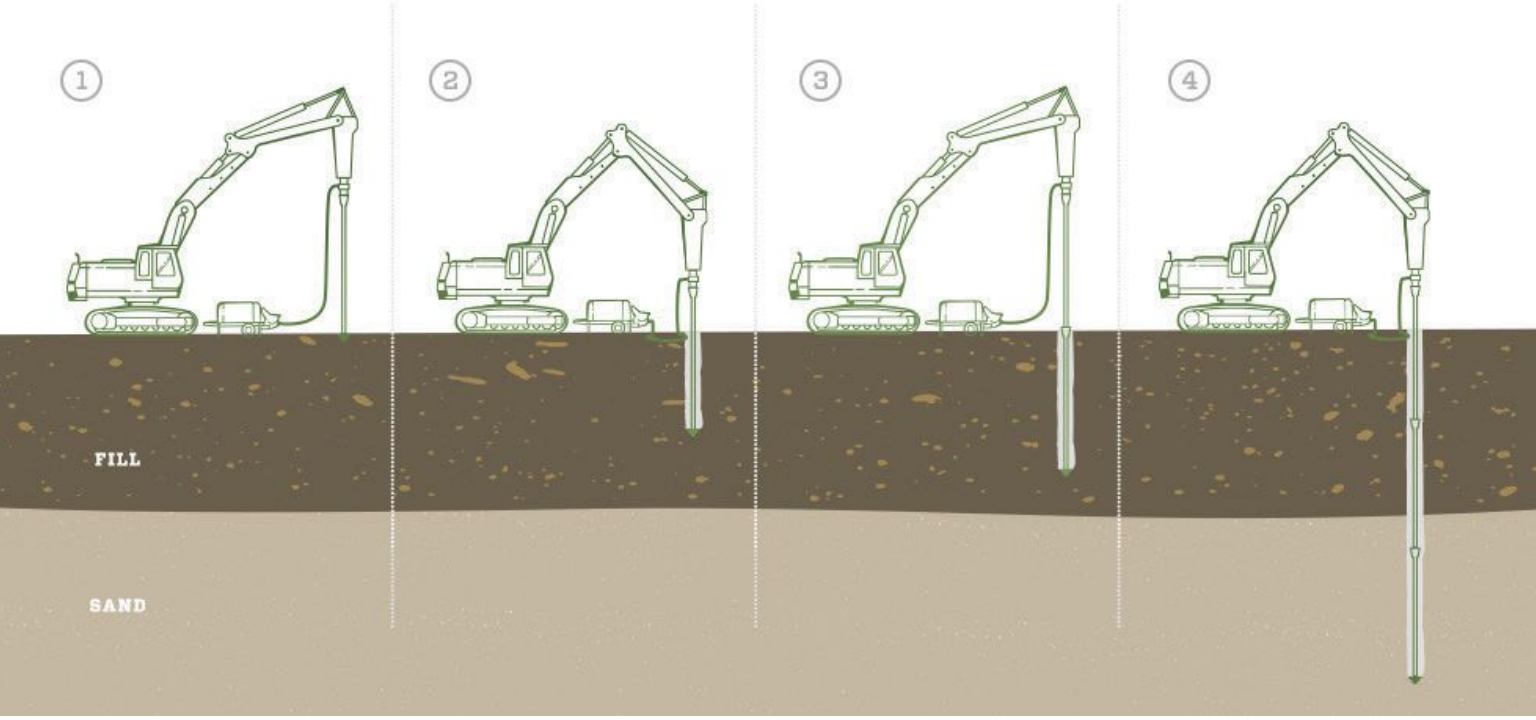
Ductile Iron Piles are installed using an excavator-mounted hydraulic hammer fitted with a special drive shank that drives the pile into the ground using a combination of the percussive energy from the hammer and the excavator crowd force. Two main types of installation methods exist for the Ductile Iron Piles: Non-grouted (dry) DIPs and grouted (wet) DIPs. While the same Ductile Iron Piles are used in each system, the installation process and accessories do vary depending on the method selected for installation.






## NON-GROUTED (DRY) PILES

1. Ductile Iron Piles installed using a non-grouted or dry approach begin by first inserting a flat or pointed driving shoe over the end of the hollow pile.
2. The 5 meter pile section is then positioned vertically (or at the appropriate batter angle if applicable) and driven into the ground using high-frequency impact energy delivered from a hydraulic hammer. The pile is driven until the belled Plug & Drive socket end is nearly at the working grade. The driving resistance (time required to drive each meter increment) is measured during driving.
3. A second DIP section is then lifted into place so that the tapered or spigot end of the second DIP section is inserted into the socket end of the existing pile.
4. The driving process is repeated.
5. This process continues until the pile terminates on refusal or achieves the required driving criteria (typically 1 inch in 50 seconds) or develops sufficient length to achieve the frictional capacity along the roughened Ductile Iron Pile surface.
6. The grout is placed either after the pile achieves the required set or later in the process after multiple piles have been installed. The reference to non-grouted pile refers to the use of the grout during the driving to fill the exterior annular space. It is almost always the case that dry piles are grouted on the interior for added strength and corrosion resistance.




## EXTERIOR GROUTED (WET) PILES

1. Ductile Iron Piles installed using a grouted approach begin by first inserting a specially-designed patented conical end cap over the end of the pile. The conical end cap is designed specifically for grouting applications and is larger in diameter than the outside pile diameter to create an oversized annular space around the pile that facilitates grout encapsulation around the exterior of the pile. The unique grouting method allows grout to be pumped directly to the base of the pile to ensure grout volume at the critical locations in the pile (compared with gravity fed pile systems that "pull-down" the grout in the pile with no way to verify the continuity of grout to the bond zone.
2. The pile is then driven into the ground using high-frequency impact energy delivered from the hydraulic hammer using a specially-designed grout driving shank that allows the simultaneous pumping of grout during driving. The grout flows from the concrete pump into the grout reservoir and shank and then down the interior of the pile. The grout fills the interior of the pile and travels out the grout ports in the conical end cap and alongside the DIP. The grout is pumped to maintain a grout return while creating the grout/soil interface to provide efficient skin friction along the friction DIP.
3. The pile is driven and grout is pumped continuously until the Plug & Drive socket end is nearly at the working grade. The driving resistance (time required to drive each meter increment) is observed during driving.
4. A second DIP section is then lifted into place so that the tapered or spigot end of the second DIP section is inserted into the socket end of the existing pile.
5. The driving / grouting process is repeated.
6. This process continues until the pile extends to a sufficient design depth in the competent bearing layer (bond zone) to develop the required frictional capacity through grout-to-ground bonding or encounters an end-bearing layer.
7. In the event that tension resistance is also required, a high-strength center bar is inserted into the wet grout to engage the frictional capacity and provide high tension resistance.





## INSTALLATION EQUIPMENT

One attractive feature of the Ductile Iron Pile system is that it uses conventional earthwork equipment for installation including a medium-duty excavator, hydraulic hammer and grout pump. The amount of specialized equipment and tooling is limited to the drive tools.

### 1) BASE EXCAVATOR MACHINES

Base crawler excavators used for Ductile Iron Piles are typically in the 18 to 30 ton service or operating weight range. Alternatively, vertical-mast equipment with a hydraulic hammer may also be used for installations. The two primary factors for base excavator selection are the need to a) have sufficient height of the hammer to reach on top of the pile for driving and b) supply the required hydraulic power to the hammer. Therefore, compatibility of the base excavator with the hydraulic hammer is extremely important to both equipment performance and pile installation.

### 2) HYDRAULIC HAMMER

The hydraulic hammer is a critical part of the Ductile Iron Pile installation process. Selection of the hammer is equally as critical to ensure 1) adequate hammer energy to drive the piles to obtain proper "set" conditions and 2) avoid overstressing and damaging the pile during driving. Factors that should be considered when selecting an appropriate hammer for DIP installation include:

- Pile diameter (98 mm, 118 mm or 170 mm)
- Grout cap diameter (if applicable) – (150 mm to 370 mm)
- Pile length
- Soil conditions (loose, dense, debris fill, etc)
- Pile design capacity
- Pile type:
  - Friction
  - End-bearing with "set" criteria
  - End-bearing on refusal

It is important that the hammer flow requirements are properly matched with the base excavator for adequate functionality. In addition, connection of the hammer to the excavator will depend on the specifics of each piece of equipment. Specialty adaptors may be required to make the proper hammer-excavator connection and need to be investigated by the installer. Many installers elect to use side-mount hammer brackets to reduce the amount of overhead clearance needed for the system installation which also reduces the excavator size requirements.

### 3) DRIVE SHANKS

Specialty drive shanks are required for installation of the Ductile Iron Piles. A solid (dry) drive shank is used for non-grouted pile installations and a grouting (wet) shank along with a grout box is used for grouted pile installations. It is recommended that the wet shank only be used for grouted pile installations and not for repeated end-bearing situations to avoid tooling damage. This damage potentially is largely because the combination of the high energy imparted during the driving process combined with the heating of the tooling that can occur without the presence of grout to act as a coolant during installation.

### 4) GROUT PUMP

A grout pump is required for installation of Grouted Ductile Iron Piles and also for filling of the interior of the pile following installation of Non-Grouted piles. A colloidal pump is typically used for mixing neat cement (cement and water) for filling the interior of piles. A piston-driven, swing-tube concrete/grout pump is recommended for pumping sand-cement grout during the installation of Grouted DIPs. Although screw pumps can deliver high rates of delivery, they are not suitable for ductile iron pile installations because of the limited discharge pressure generated.

Like hammer selection, it is important that the grout pump be selected so that it is large enough to provide sufficient pumping pressures to introduce the grout at depth in the pile, but is not too large that it causes blockages in the line or over-pressurizes the system. Manufacturer recommendations indicate a maximum pumping pressure up to 1,000 psi (70 bars) and with a flow rate of 12 cfm (20 $m^3$/h). The pump stroke size is also critical to avoid plugging. Pump strokes of ¼- to ½-cubic foot per stroke are well-suited for DIP installation.

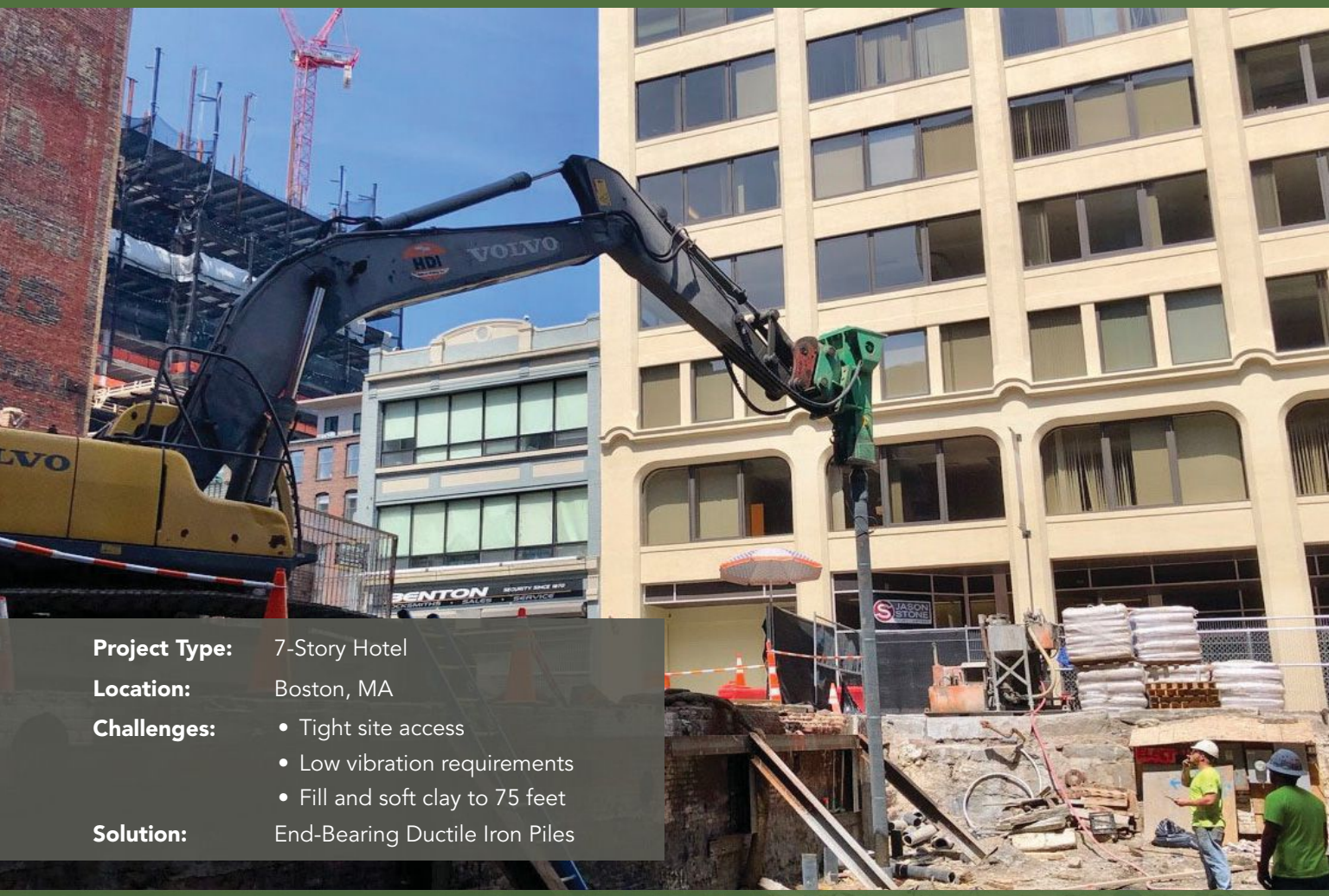
During grouted DIP installation, the grout pump lines are connected to the grout box attached to the grouting (wet) shank in the hammer. Since the connection to the wet shank is a 2 inch (50 mm) connection, hose reducers are often required from the 4 inch (100 mm) or 6 inch (150 mm) line extending from the pump.

View more at DuroTerra.com. ■

# THE DUCTILE IRON PILE ADVANTAGE:

DUROTERRA™

# Micropiles Made Simple.




| | |
|---|---|
| **Project Type:** | 7-Story Hotel |
| **Location:** | Boston, MA |
| **Challenges:** | • Tight site access<br>• Low vibration requirements<br>• Fill and soft clay to 75 feet |
| **Solution:** | End-Bearing Ductile Iron Piles |

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

## *BENEFITS:*

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

## *SOLUTIONS FOR:*

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

## CONTACT US

FOR MORE INFORMATION OR PROJECT FEASIBILITY

781.817.6053 • info@duroterra.com
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