Foundation DRILLING

OCTOBER 2016

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Soilmec's New Blue – ADV / Hit Drill Rigs and Discrepile and Traction Compaction Tooling

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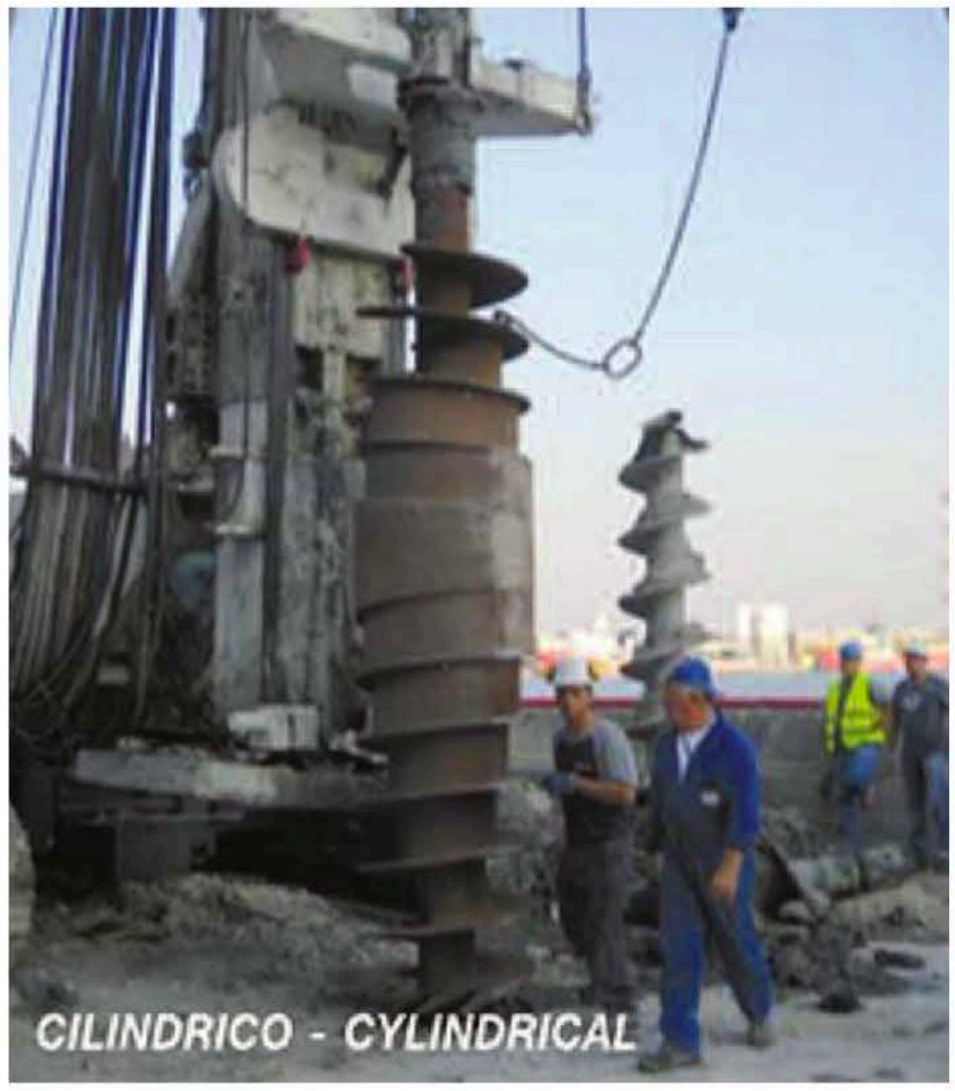
Drilled Displacement Piles (DDPs) are cast-in-place concrete piles that are formed with little or no soil removal from the ground. This is a specialized technology in which a pile is constructed using a process where (a) a specially designed tool is advanced into the ground using both rotation and downward thrust ("crowd force") to displace the soil radially outward into the surrounding formation, and (b) concrete is injected and steel reinforcement (if required) is inserted to fill the created hole and construct the structural element.

DDPs have been used as structural foundation elements and for ground improvement. They offer numerous advantages that have contributed to their increased use especially for construction in urban areas, in contaminated environments (landfills and industrial facilities), in congested spaces, and in close proximity to existing structures (around buried structures and utilities). As long as the soil can be displaced and compacted, this technique is ideally suited for a wide spectrum of soil conditions ranging from loose/soft to medium-dense/firm and from sandy gravel to clay (relative density ≤ 65%; undrained shear strength < 2,000 psf). In applicable ground conditions, the installation process results in increased unit values of side shear and no relaxation compared to non-displacement piles. Therefore, the load-displacement response of a DDP is stiffer than that of a comparable non-displacement pile, which, consequently, enable DDPs to achieve a given load resistance at a shorter length. Some of the benefits of DDPs include the following:

- Relatively rapid construction from high daily production
- Minimal amount of soil removal (spoils)
- No need for stabilizing fluids (slurry) or steel casing
- Reduced environmental concerns - minimal noise and ground vibrations compared to impact driven piles
- Lowered risks and costs associated with transport and disposal of (contaminated) spoils
- Cleanliness of the working area - reduced risk of injury to onsite personnel
- Significantly lower concrete overbreak than with conventional piling methods
- Increased unit side friction and end bearing resistance achieved through the compaction of the surrounding soil, resulting in lower cost per ton of load.

Soilmec Displacement Tools

The cylindrical ("Cilindrico") displacement tool is well suited for soft ground conditions (loose to medium-dense sands, soft clays, and organic soils), whereas the conical ("Conico") displacement tool is well suited for stronger ground conditions (medium-dense to dense sands and stiff clays). Four main sections comprise these tools: (1) a drilling tip, (2) a lower section with partial auger flights that move the soil upward toward the displacement body, (3) a central cylindrical body that stabilizes and displaces the soil, and (4) an upper section with partial auger flights that move the soil downward toward the displacement body. Soilmec manufactures and provides the conical tools in modular form to optimize productivity. Cylindrical and conical displacement tools are able to form boreholes with diameters ranging from about 350 to 600 mm (about 14 to 24 inches).



Trevi Cylindrical Displacement Tooling

Trevi Conical Displacement Tooling

(continued on page 62)

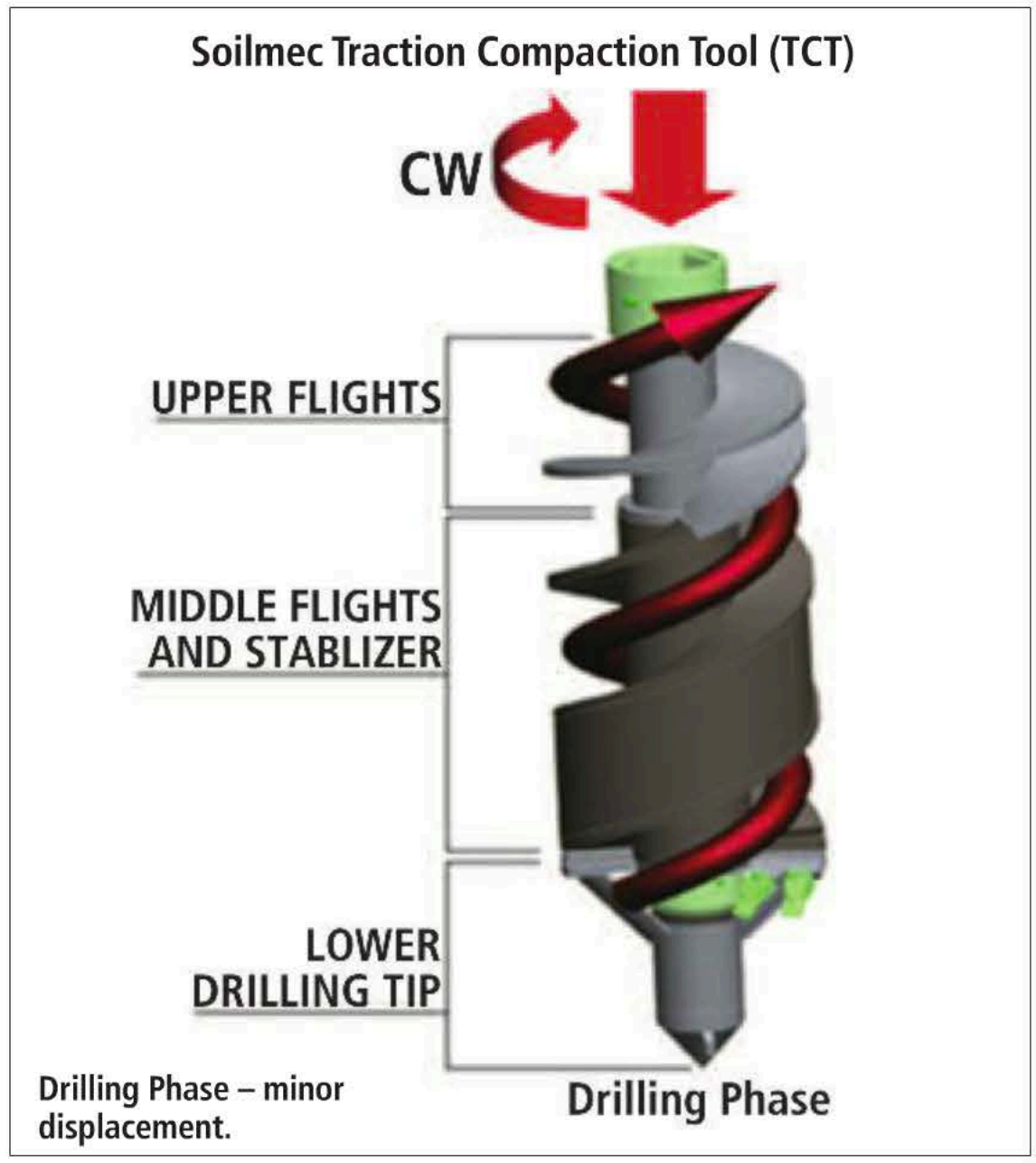
The general requirements for a drill rig capable of constructing displacement piles include (a) a rotary head capable of delivering rotation of 20 to 25 rpm, (b) a rotary head capable of delivering 200 to 250 kN-m (147,000 to 185,000 ft-lbs) of torque, (c) a pull down system with a crowd force of at least 200 kN (45,000 lbs); and (d) a pull-up system capable of providing an extraction force of at least 200 kN (45,000 lbs). In Belgium and the Netherlands where the DDP technique has a long history, drill rigs with double this amount of torque and crowd are used to achieve the greatest productivity.

Soilmec SR-95 with Conical Displacement Tooling on a project in California. (Photo courtesy of Condon-Johnson & Associates)

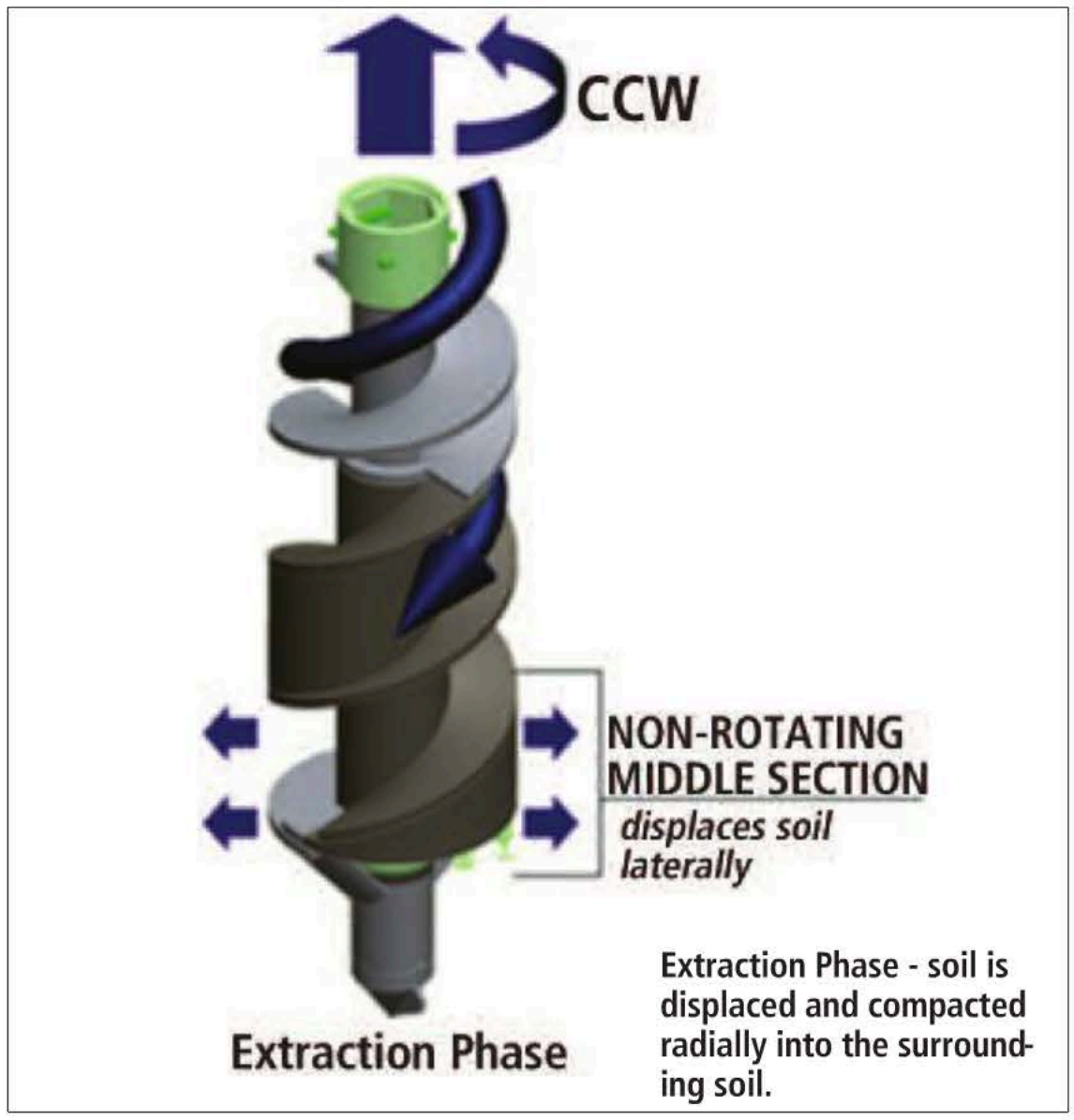
Soilmec Traction Compaction Tools

In general, the maximum achievable diameter and depth are limited by the type of tooling and the capabilities of the drill rig: (a) the push/pull down force (crowd), (b) the pull up/extraction force, (c) the maximum available rotary torque, and (d) the height of the drill mast. For conventional DDPs, the soil is compacted during the drilling or penetration phase, thereby requiring the use of a large, heavy, powerful drill rig to provide the crowd force and torque needed to achieve the desired diameter, depth, and displacement.

Soilmec S.p.A. patented a DDP technique using the Traction Compaction Tool (TCT) where a large proportion of the compaction occurs during the extraction/concreting phase instead of all of the compaction occurring during the drilling phase. During drilling, the tool and drill string are rotated in a clockwise rotation and penetrate the ground using the single rotary drive and crowd force provided by the drill rig, resulting in partial compaction and causing much of the material to remain in a coiled mass as the tool moves downward. When the desired depth is achieved, the TCT is rotated



counterclockwise and the central element of the tool shifts to full displacement during the extraction and concreting phase.



Because the total volume of the displaced soil is compacted during both penetration and extraction, the peak friction between the TCT tool and the in-situ soil is reduced so wear and heat are minimized. Therefore, the torque, power, and crowd force required to turn the TCT and penetrate the ground is greatly reduced by utilizing this different work cycle. Moreover, since the drilling rig is utilized during drilling and extraction, the rig is operating more efficiently and productively than rigs used to construct conventional DDPs.

DP / TCT line - *Model*	SR-45	SR-75	SR-95	SR-125	SR-145
Max pile diameter (mm/inch)	350 / 13.8	600 / 23.6	600 / 23.6	800 / 31.5	800 / 31.5
Max TCT diameter (mm/inch)	400 / 15.75	800 / 31.5	800 / 31.5	1000 / 39.4	1000 / 39.4
Max pile depth (m/ft)	20 / 65.6	22.7 / 74.5	25.5 / 83.7	28.5 / 93.5	31.5 / 103.4
Max pile depth (m/ft) *(with lattice mast extension)*	23 / 75.5	30.7 / 100.7	33 / 108.3	36 / 118.1	39 / 128.0

Soilmec ADV (Advanced) and HIT (High Technology) drill rigs for Displacement Piles using the Traction Compaction Tool (TCT)

Consequently, a smaller drilling rig can be used to achieve a comparably sized DDP constructed using conventional means.

On a project site in Illinois, ADSC Contractor Member Hayward Baker, Inc. (HBI) has been utilizing a Soilmec SR-75 outfitted with a 400mm (15.75 inch) diameter TCT tool to install drilled displacement piles through overburden and clay of varying strengths into the firm clay layer to depths ranging from 40 to 45 feet. Using the SR-75/450mm TCT at this site, HBI has achieved 2,000 LF of production (completed piles) per day, about double its bid estimate.

Flexibility

Displacement piling construction does not require a dedicated specialized drill rig. The new Soilmec product lines, ADV (Advanced) and HIT (High Technology), for hydraulic rotary piling rigs can be utilized for the installation of various deep foundation techniques using a single platform. Conversion kits facilitate quick changeover between different techniques spanning from large diameter piles (LDP), continuous flight auger (CFA), cased auger piles/cased secant piles (CAP/CSP), drilled displacement piles (DP), turbo-jet (TJ) soil mixing, and for low headroom (LHR) conditions.

Quality Control

It is essential to monitor and control various parameters during construction that affect the integrity and performance of a DDP. The different equipment and drilling/engineering parameters can be monitored and recorded continuously using the Soilmec automated Drilling Mate System (DMS), which is integrated directly into each of the Soilmec drilling rigs. The DMS is a high-tech, fully integrated, interactive tool whose interface is located in the rig cabin, which allows the rig operator to monitor and accurately control the machine in real time. Data from an array of sensors recording the different parameters is transmitted to the cab, can be displayed on an easy-to-use touchscreen interface, can be stored on a flash drive, or can be streamed via cellular networks to a remote computer. Some of the important drilling / engineering parameters include the drilling depth, penetration speed, rotational speed of the tool, inclination of the rig mast, rotary torque, crowd force, lifting speed, extraction force, concrete pressure, concrete flow, and total volume of pumped concrete. Controlling and monitoring the various parameters during drilling and concreting assists with ensuring that the quality of the finished product consistently meets project specifications.

Summary

By maximizing the drill equipment operability with the Traction Compaction Tool, smaller drilling rigs can be used to achieve the desired diameter and depth of the DDPs, resulting in reduced operating and transport costs without sacrificing quality and productivity. Specific advantages of constructing DDPs using the TCT include the construction of larger diameter elements (up to 800 mm (32 inches)), the use of smaller/lighter drill rigs, high rates of daily production, lower operating and transport costs (compared to conventional DDPs and non-displacement piles), and enhanced quality of the finished element. Your Soilmec agents are prepared to assist you in selecting the proper tooling and drilling equipment for all of your particular drilling needs and conditions.

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The information that appears in the Equipment Innovation department is provided by ADSC Associate Members through the association's Associates Committee. Submittals should be sent to Committee Chairman, Roy Kern at: akern@ecanet.com. (Editor)

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