TECHNOLOGY

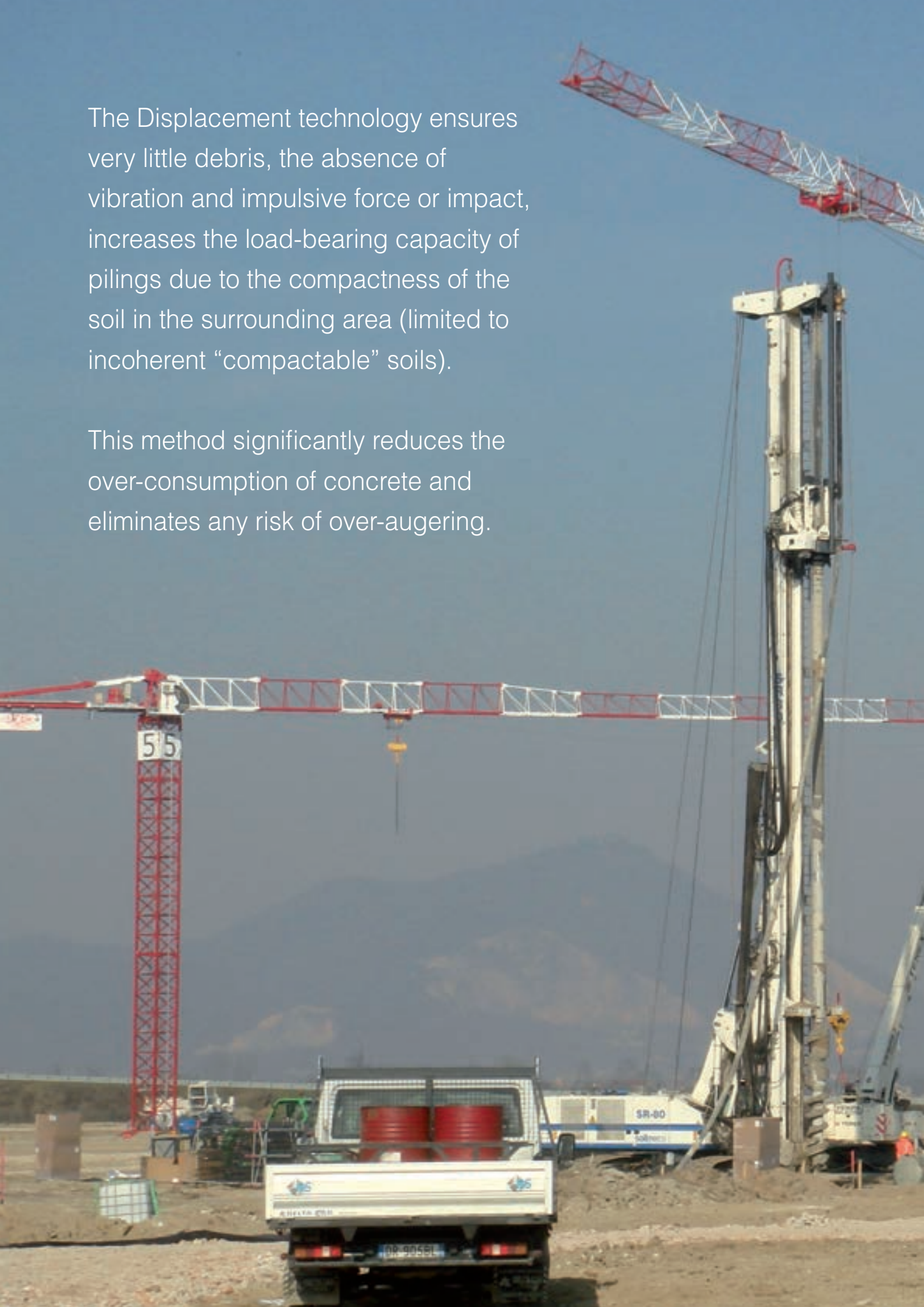
Displacement Piles

soilmec

Drilling and Foundation Equipment

The Displacement technology ensures very little debris, the absence of vibration and impulsive force or impact, increases the load-bearing capacity of pilings due to the compactness of the soil in the surrounding area (limited to incoherent “compactable” soils).

This method significantly reduces the over-consumption of concrete and eliminates any risk of over-augering.



High daily productivity

Applicable to LDP/CFA medium-big size rigs

Pile diameter ranging **from 300 mm to 1000 mm**

Pile depth up to **39 m**

Technology

With respect to driven piles, when drilling a pile, driller has always had to solve the problem of the bore walls collapsing. Use of casing, bentonite and polymers is the classical solutions.
With the CFA method, in which soil extraction and concreting are simultaneously performed, the bore remains always full, either with spoils or concrete. Therefore the problem of wall collapse does not exist.
With the displacement pile technology, in which the tool drills the soil and displaces it laterally toward the bore walls, situation becomes very close to driven piles: no more spoils, clean job site!
Even if this type of piles is since years quiet popular especially in the north of Europe, more recently, the increasing costs to dispose of excavation spoils have promoted displacement pile method development.
Also the environmental problems in the contaminated soils that are led to the development of soil compaction tools which eliminate or minimise the quantity of spoils brought to the surface during pile execution have given their contribution to spread the method.
In particular, the risks associated with transportation of contaminated soil, as well as the costs of their disposal, have been usually a deterrent to construction development in polluted areas. Consequently the reclamation of these areas requires an important use of compaction technologies.
Also, being noise and vibration free, compaction (displacement) is an interesting alternative to driven piles, especially in urban areas.

Construction stages


TCT tecnology


DP tecnology

In principle the execution of the compact pile consists in removing the soil located inside of the pile volume and displace it (here is the pile name origin) to the bore walls under the tool pressure created by the tool shape. The displacement pile feasibility is consequently related to soil nature deformability.

In case of rocky soil, as limestone for example, even if the rock resistance is weak enough to let the tool teeth scratch it, there is no way to let the spoils to be recombined in the surrounding rock by means of the mechanical pressure applied by the tool.

Compaction is possible if the soil is deformable, that supposes either the presence, like in sand, of “free spaces” that will be “plugged” by the drilled material integrating the surrounding soil, or the soil plasticity, like in clay, allowing the spoils to be spread on the walls like “butter on the bread”.

In the first case, the tool is facing cohesionless soil (called also frictional soil) made of solid grains, as sand or gravel, whose strength depends on friction between particles. The tool forces the new spoils grains between the original soil grains causing their reorganisation.

In the second case, the tool is facing cohesive soil such as clay or clayey silt whose strength depends on the surface tension of capillary water between the soil particles. In this kind of soil the tool “displaces” the surrounding soil against the pile wall.

In the cohesionless soil, the compaction mechanism is therefore active since there are enough voids to be filled that corresponds to a certain level of soil original relative density, which corresponds to a certain volume of porosity, is still available to be plugged.

Compaction techniques applicability

For cohesive soils, compaction is active since the wall material will accept plastic deformation.

In the practice, the applicability of displacement techniques are possible when, for:

• Cohesionless soils (mostly loose sandy soils) up to a maximum relative density for of 65%. Above such a limit, compaction of loose soils becomes difficult.

• Cohesive soils (stiff soils) presenting an undrained cohesion not exceeding 120 kPa. Above such a limit, cohesive soils are difficult to compact.

A glance on above sketches may suggest some consequences about properties evolution of pile surrounding soil. In cohesionless soils, the structure reorganisation and consecutive increase of local density of the pile surrounding soil, have positive consequences respect to final pile behaviour. At the opposite, in cohesive soil, because compaction includes just plastic deformation of the pile surrounding soil, consequences on pile behaviour should be limited.

Construction stages

As far as rigs and items are concerned, DP method and CFA method are quiet close. Nevertheless, for DP, instead of using a long auger string, the tool can be mounted at the lower end of a hollow drill string (without flights).

Phase 1

Using traditional DP tools, cylindrical or conical, the compaction is performed by pushing the tool down, while drilling clockwise. As above-mentioned, the removed soil is pushed laterally against the bore walls.

During the soil penetration phase, the bore mouth and walls above the tool are not completely consolidated.

Phase 2

Once the requested depth has been reached, the drilling string - still rotating clockwise - is lifted up while concrete is pumped through the hollow string and the tool bottom pivoting gate.

During tool lifting up, the tool stabilizer compacts once more the bore walls pushing any spoils eventually fallen from the bore part located above the tool against the walls.

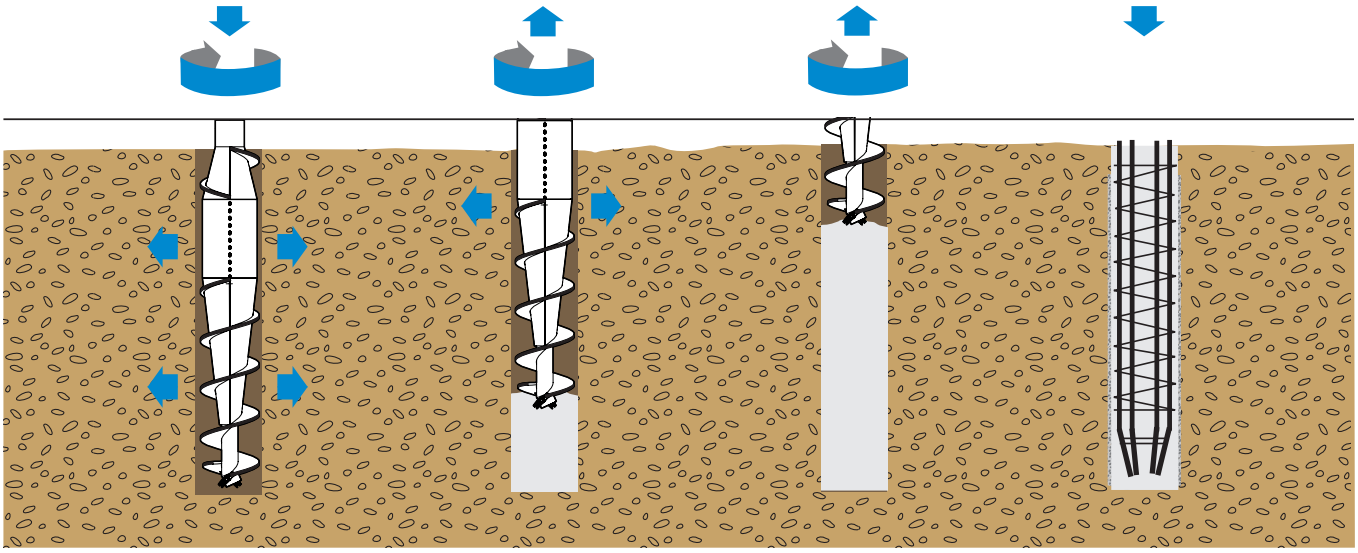
Phase 3

Steel reinforcement installation: if required, the steel reinforcement (cages, profiles or beams) is finally lowered into the fresh concrete.

PHASE 1
Drilling & Compaction

PHASE 2
Extraction, contemporary pouring
of the concrete and final wall stabilization

PHASE 1
Cage insertion



Drilling tools


"Cylindrical"


"Conical"

"Modular MDT"


"Pirucca"

TRADITIONAL DP TOOLS: "Cylindrical" & "Conical"

Classical cylindrical tool comprises four sections:

1) The drilling tip to be fitted with teeth adapted to soil consistency.

2) A bottom helix section with right-hand flight that brings the soil upwards and starting the compaction.

3) A central cylindrical stabilizer, that stabilizes the soil laterally producing the actual compaction diameter.

4) An upper helix section with left-hand flight that displaces falling soils pushing it against the wall and to the stabilization portion of the tool.

As CFA tools, displacement tools are provided with a hollow passage and a pivoting gate for concrete casting.

This tool type is in use in the industry since 20 years approximately and presents a cylindrical general shape. For better soil penetration, tools having a general conical shape have been also developed in the past. Conical tools are also provided with conical picks or cutting teeth according to the soil nature to be penetrated. Respect to cylindrically shaped tool, the conical one eases the penetration in dense cohesionless soils and stiff cohesive one.

INNOVATIVE DP TOOLS: MODULAR "MDT"

As stated above, respect to cylindrical tool, conical one are securing a better soil penetration in consolidated soils, nevertheless also flight pitches have to be adapted to soil nature in order to lift up the spoils and compact them against the bore walls, especially when un-compressive layers has to be overpassed.

MDT modular displacement tools are offering for various pile diameters different drilling sections to be mounted to a common stabilization section. Beside the conical shape that ease the soil penetration, a medium flight a long pitch eases also the spoils transport and a progressive compaction of stiff clay and medium dense cohesionless soils.

Short pitch is preferable for organic and very loose and fine sands. Medium pitch is suitable for medium sands and clays.

INNOVATIVE DP TOOLS: SELF ROLLING TOOL "Pirucca"

"Pirucca" is a Soilmec patented displacement tool that allows to reduce the torque required during DP executions, ideal application for soft soils. Due to the eccentrical shape and rolling displacement portion, all the frictional force needed for compaction, has been reduced, thus a wider installation on lighter rigs is also possible.

Tool is available for 17.7" - 19.7" - 23.6" piles.

TCT - Traction Compacting Tool

A relevant way to size down the DP rigs - or enlarging their field of application - consists in reducing the necessary crowd. Thus SOILMEC patented TCT (Traction Compacting Tool) piles, carried out by traction instead of crowd a simpler way for downsizing the displacement rigs, typically used in CFA configuration (having high extraction capacities).

TCT tool for TCT piles

TCT “Traction Compacting Tool” includes three parts:

1) the lower tip, fitted with teeth, and provided with a concrete gate, is rigidly connected to a smooth drilling string, generally smooth rod, or in special case also flight auger

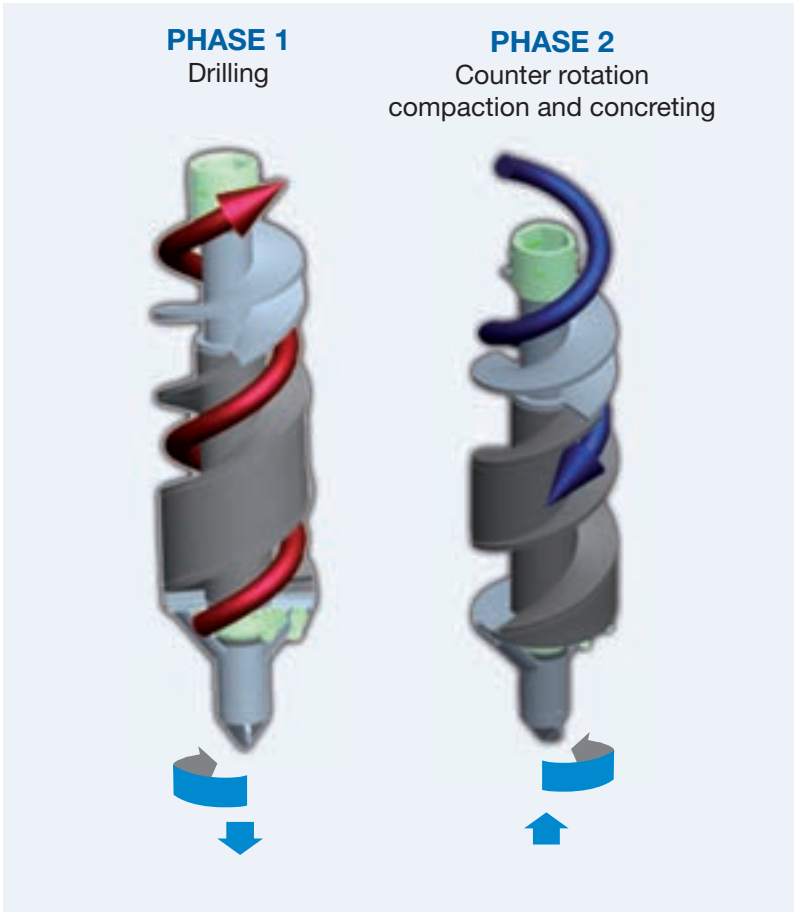
2) the upper part, fitted with flights, which is rigidly connected to the string

3) the middle part, located between upper and tool tip, is freely rotating, may turn around the fixed portion connected to the string by a certain angle. It is fitted with flights and the bore stabilizer.

TCT Operative Sequence

Phase 1
The drilling phase is performed, as with CFA tool, by clockwise rotation under a light crowd. The position of the flights of lower and upper part allows the excavated soil to climb up anticlockwise. Respect to CFA, because the tool length is short, the friction developed between the soil located on flights and the soil wall is limited and correspondingly the request of torque.

Phase 2
Once the drilling depth has been reached, the drilling string is rotated anticlockwise. Because of the friction between the soil located on the tool middle part and the soil walls, the middle part does not turn. Upper and lower parts, connected to the string, are turning together. This rotation causes a consecutive flight positioning that shapes a cover above the concrete gate. This cover builds a concreting chamber that secures the full protection of the concrete when injected against spoils pollution.
During concreting, the tool is lifted up and kept turning anticlockwise. The soil left above the tool during the descent phase is therefore, brought down, blocked by the bottom cover and pushed against the bore walls by the middle stabilizer.
The compaction is therefore executed in extraction, taking advantage of the full rig extraction capacity.
This tool type may be executed for DP piles ranging from 15.7” to 31.5” diameter.
Taking advantage of traction instead of crowd all rigs in CFA configuration may be converted to DP to be carried out with TCT-180 tools. This allow to use lighter machines respect to those to be used with classical DP tools.



TCT - Traction Compacting Tool

TCT and TCT-S Piles ADVANTAGES

Respect to drilled piles, TCT and TCT-S piles behaviour can be compared with driven piles behaviour almost for cohesionless soil. As mentioned here above, and schematically said, in cohesionless soils, displacement produces - as impact driving - the increase of the pile surrounding soil relative density by reorganisation of the soil structure.

Consequently, TCT and TCT-S piles are presenting a better bearing capacity respect to drilled and CFA piles to be compared with impact driven piles.
In a similar way, but with a very limited amplitude, the same occurs in cohesive soils. In such soil conditions impact driven piles con offer similar behaviour to TCT-S piles, preferably used for this purposes.

Using TCT technology and downsizing the LDP/CFA rigs, is consequently reduced the operating cost compared to DP technology.

TCT-S “TCT Screw Pile”

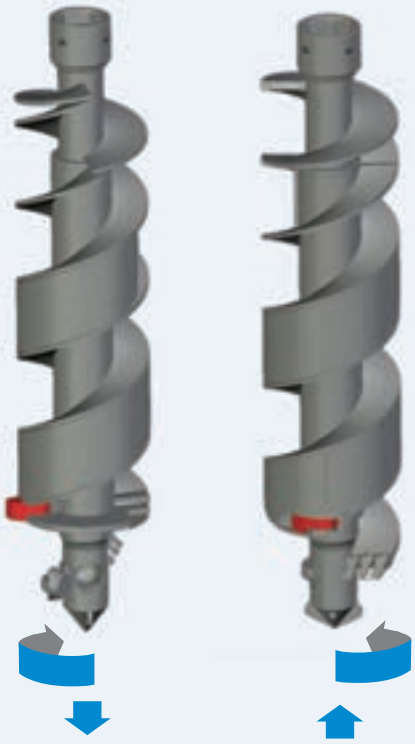
The skin surface of the TCT pile, may be increased -and consequently its bearing capacity too- by changing the pile skin surface from smooth to screw type (TCT-S). In such a case, the active pile diameter is not any more the one taken in the screw groove -corresponding to smooth skin, but the one taken at the screw helix tip. This corresponds to the fact that being the pile skin surface increases, the friction between surrounding soil and pile increases too.

In the practice, the screw type skin is obtained by fitting the TCT-S tool drilling tip with a retractable teeth that a cam forces to protrude out of the general tool shape during counter rotation phase.

Controlling rotation and lifting speed, the teeth ploughs a groove in the pile-surrounding wall, which is filled by concrete. From smooth skin, the pile becomes screw type skin.

PHASE 1
Drilling

PHASE 2
Counter rotation compaction and screwing forward the concrete



Job site logistics

DP & TCT Drilling rigs

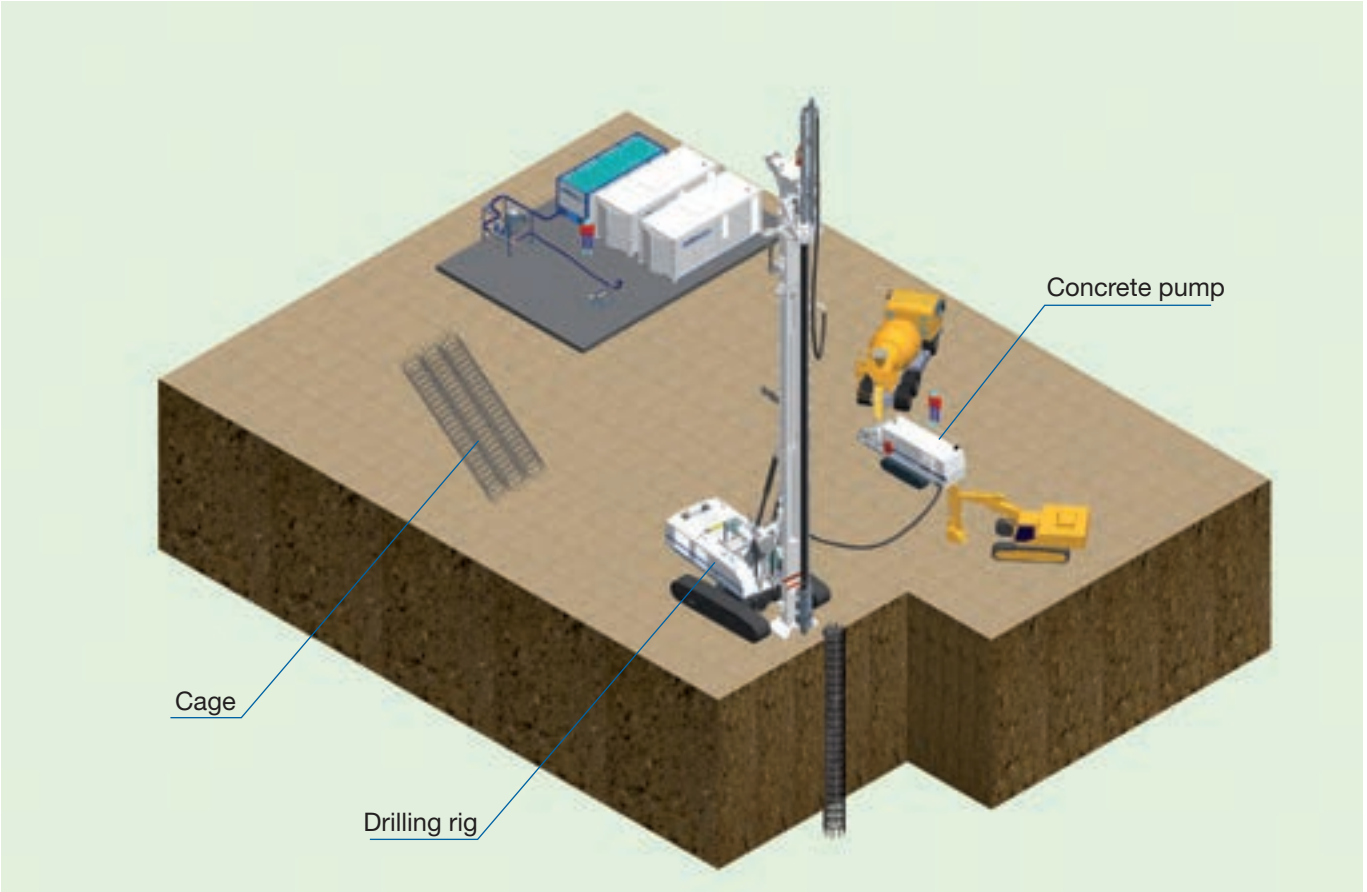
Even if under certain aspects displacement method is closed to CFA, some differences are sensitive. The main one concerns the soil penetration phase. While in CFA, during drilling, the auger has to be retained, or lifted up, from time to time in order to cut the soil, at the opposite, to carry out DP, the tool has to be strongly pushed down to force the soil against the bore walls. Rearrangement of the soil structure during compaction requests substantial quantities of energy that appear under the friction resistance developed by the material. Therefore, suitable rigs should be able to satisfy such energy requirements under the form of torque and crowd force.

While in CFA method, the extraction force is the sensitive characteristic, in DP, because the compaction is still in completion during the extraction phase, above-mentioned parameters are the most important.

When using classical tools, that operate displacement under crowd force, rig configuration can be completed with rear outriggers to let the rear of the machine react to the front crowd apply on the tool.

Based on job site experience in medium soil conditions (relative density lower that 65%, undrained cohesion less than 120 kPa), the rigs chart shows what are the rigs capacities in terms of pile diameters and pile depths.

It appears also that the execution of medium sized DP piles requires heavy equipment developing high torques and high crowd forces in order to overcome the soil friction resistance.



Drilling tools

Standard drill rods

Hollow strings are fitted with hex male/female couplings connected with pins. The 5” diameter internal passage is used to bring the concrete down to the bottom gate installed on the tool.
Sections are available: 6.56, 9.84, 13.12, 19.69 ft length.

According to the torque value to be applied on rods, two different coupling are available: XHD and 25HD.

Recently, SOILMEC has developed a new type of rod YHD useful also for TURBOJET® techniques and having similar strength of XHD type coupling rods.
By bolting just a few parts together, the internal 5” tube can take a rod with an internal diameter of 2” for injecting the cement grout at high pressure using TURBOJET® technology. The seals mounted on the internal tube, with anti-extrusion rings, guarantee a seal up to 5801 psi bar pressure.
Interchangeability is guaranteed by adaptors.
Workers safety has substantially conditioned the DP and TCT tools design. Thus the tool concrete gate is operated without human intervention. It is shaped in order to let the concrete pressure open it.
On the other hand, after concreting, as soon as the next pile it started with the drilling tip penetrating into the soil clockwise augering, drilled soil pushes back the gate door and close it.

Semi-displacement drilling rods

Special rods can be used for semi-displacement piles execution. These rods, having a narrow flight auger around the smooth big size tube, are used when soil conditions are intermediate between very heavy/stiff and stiff (limit of displacement pile applicability).

Special drilling rods for cage reinforcement insertion

Special rods and TCT tools can be supplied also for cage reinforcement insertion at the completion of the drilling phase. Using a lost bit, and increasing the internal tube diameter, is possible to insert the cage before starting the pouring of the concrete.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MARIO PRIMO
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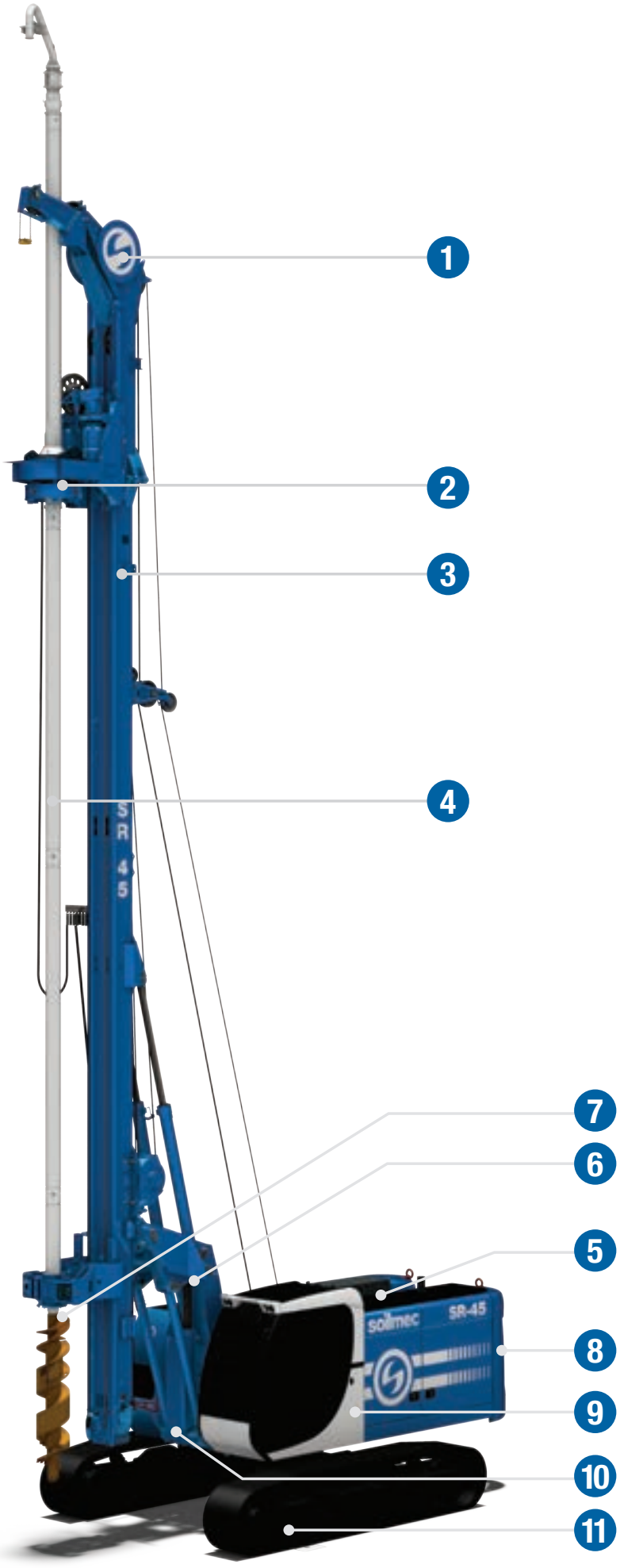
Soilmec Equipment

Displacement pile drilling rigs
The SR multifunctional rigs are easily convertible to displacement pile technology by fitting a large dimensioned crowd winch developed by Soilmec since the 1990's. The rig configuration can be completed with rear outriggers and mast extension to improve stability and performance. In addition to the Soilmec patented TCT, traction compacting tool, the compaction is executed in extraction phase taking advantage of the full rig extraction capacity.



1. CATHEAD
2. ROTARY HEAD
3. SELF ERECTING MAST
4. DRILL ROD
5. WINCHES
6. PARALLELOGRAM SYSTEM
7. DP TOOL
8. COUNTERWEIGHT
9. TURRET
10. CAB
11. UNDERCARRIAGE

Soilmec Equipment

Advanced range

Multipurpose drilling rig equipped with double independent rotary heads for cased augered and secant piles method

ADV

ADV line - Model	SR-45	SR-75
Max pile diameter	350 mm	600 mm
Max TCT diameter	400 mm	800 mm
Max pile depth	20 m	22,7 m
Max pile depth with lattice mast extension	23 m	30,7 m

High technology range

Multipurpose drilling rig equipped with double independent rotary heads for cased augered and secant piles method

HIT

HIT line - Model	SR-95	SR-125	SR-145
Max pile diameter	600 mm	800 mm	800 mm
Max TCT diameter	800 mm	1000 mm	1000 mm
Max pile depth	25,5 m	28,5 m	31,5 m
Max pile depth with lattice mast extension	33 m	36 m	39 m

All technical data are purely indicative and subject to change without notice

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SOILMEC Spa distributes machinery and structures all over the world, supported by SOILMEC Spa subsidiary companies and dealers.
The complete Soilmec network list is available on the web site www.soilmec.it

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