Bored pile technology dates back to the beginning of the last century.

Nowadays, with increasingly powerful equipment available and borehole walls supported by bentonite or polymer slurry, this technology can be used to construct foundation piles up to 4 m in diameter and 100 m deep.
Bored pile technology dates back to the beginning of the last century. Drilling diameters up to 4,000 mm. Drilling depth over 100 m.
The large diameter bored piles are foundation structure characterized by a cylindrical shape with a diameter larger than 600 mm; manufactured by excavating ground through a rotary drilling equipment with a complete soil removal and cast in place by casting concrete into the borehole.

The bored piles construction entails two main steps, the drilling phase (Demolition - Removal - Stabilisation) and the construction phase (Reinforcing cage - Casting - Curing).
Drilling stages
To stabilize the borehole, three methods can be used:

- **Dry pile construction**
  Where the soil is stable, stabilisation operations can be avoided.

- **Wet pile construction**
  Drilling mud (bentonite and polymer mud) is used to fill the borehole while drilling and prevents the borehole walls from collapsing.

- **Cased pile construction**
  To drill the borehole, casings are used to maintain open the borehole.

The next step is the construction of the pile: firstly the reinforcing cage is lowered into the hole and then concrete is cast. Each of these methods have their own areas and applicability.

**DRY EXCAVATION**
The construction process consists of drilling the pile, removing loose material from the borehole, placing the reinforcement cage, and concreting the shaft.
Excavation WITH DRILLING FLUIDS

When drilling through loose soil or very soft clay below the water table, special bentonite or polymer slurries are used to stabilise the borehole walls. Thanks to the greater specific weight of bentonite slurry compared to water and its capacity to create a waterproof layer over the borehole walls, these slurries, when applied for more than at least metre above the water table, help make the shaft watertight, preventing the walls from collapsing.

The drilling slurry, whether it is bentonite or polymer-based, is produced on site using specific high turbulence mixing plants.

The following quantities of bentonite or polymer are used to prepare the slurry:

- bentonite: 30-70 kg per 1,000 litres water
- polymer: 0.5-3 kg per 1,000 litres water

It is important to have a constant supply of slurry on site in case its level suddenly drops, should workers encounter cohesionless, particularly loose soil or underground cavities.

The slurry must have certain rheological characteristics, such as density, viscosity and sand content, in order to effectively stabilise the borehole and these parameters must be checked periodically during work.

Once drilling operations are complete, the bottom of the borehole is cleaned using a special “cleaning” tool and the slurry in the borehole is desanded. This is carried out by lowering a centrifugal pump to the bottom of the hole and pumping the slurry to a special piece of equipment called “desander”. At the desander, the slurry is fed through a series of vibrating screens and hydrocyclones which separate it from soil residues before conveying it back to the borehole. This process operates in a continuous cycle so the slurry in the borehole remains at the same level.

Excavation WITHOUT DRILLING FLUIDS

If drilling fluids cannot be used, boreholes can be supported by temporary casings. As for the foreshaft, the temporary casing can be driven into the ground using the rotary head of the drilling rig (up to 15-20 m) or a hydraulic vibratory hammer connected to a service crane.

As a general rule, the techniques described above are not effective at depths greater than 20 m and the temporary casing can only be driven using a special piece of hydraulic equipment called “casing oscillator”.

Construction stages

STAGE 1
Drilling

STAGE 2
Desanding

STAGE 3
Insert reinforcement

STAGE 4
Cast concrete

STAGE 5
Finished pile
Excavation
WITH CASING SUPPORT

Segmental casing is used as a temporary or permanent support for a bored piling system with deeper unstable soil conditions. It is utilised during the drilling stage and can be installed and extracted by using a drilling rig or an oscillator attached to a rig, service crane or power pack. A large casing driving plate is fitted under the rotary to couple the first 1.5 m-casing section. The soil therein is removed by means of boring tools such as an auger or drilling buckets. The sections are joined using mechanical joints until the desired length is achieved.

During the concreting stage casings are withdrawn in segments, extracted by the piling rig and or oscillator. Segmental casing method can be applied to foundation piles, secant pile and contiguous retaining walls. Casing drilling is recommended in soils with rocks or boulders which tend to displace the kelly bar from the drilling axis, and thus cause serious damage to them. There are two type of casings:

Temporary Casing: Temporary casing is used to retain the sides of the borehole only long enough for the fluid concrete to be placed. The temporary casing remains in place until the concrete has been poured to a level sufficient to withstand ground and groundwater pressures. The casing is removed after the concrete is placed.

Permanent Casing: The use of permanent casing is implied by its name; the casing remains and becomes a permanent part of the foundation. An example of the use of permanent casing is when a drilled shaft is to be installed through water and the protruding portion of the casing is used as a form.

Construction stages

**STAGE 1**
Casing + Drilling

**STAGE 2**
Insert reinforcement

**STAGE 4**
Cast concrete

**STAGE 4**
Casing extraction
INSERTING THE REINFORCEMENT CAGE

The steel reinforcement cage is inserted in the shaft using a service crane of a suitable capacity. As it is being lowered, concrete or plastic spacers are applied to the outside of the cage to ensure the designed concrete cover.

In order to guarantee sufficient concrete cover at the bottom of the pile, the cage is supported and suspended 15-20 cm from the bottom of the hole. Upon request, the cage can be fitted with 2” iron pipes on the inside to carry out non-destructive sonic tests.

CASTING THE CONCRETE

Once the cage has been inserted, the borehole is filled with concrete.

To do this, a string of steel pipes with an internal diameter of no less than 250 mm is lowered down the centre of the shaft. As a general rule, the string is made up of 2 or 3 metre long sections which are connected to each other until they reach the bottom of the hole. A funnel is placed at the top of the string and the concrete is poured into it.

The concrete flows down the pipes and, when it reaches the bottom, it begins to fill the hole, rising back up. Thanks to the considerable difference in density between the two fluids, the slurry does not mix with the concrete but is forced up towards the surface where it is collected in special slurry pits, ready to be used again. As the concrete rises inside the borehole, the string is shortened to ensure that no more than 3-4 m of piping is immerged in the wet concrete at any one time.

Once the concrete has reached the pre-established level, the pouring stops and the string are removed completely.

CURING

Once the curing time of concrete has elapsed, an excavation is made around the foundation pile group. Pile heads are trimmed to leave the reinforcement bars only.
A typical jobsite constructing bored piles through slurries will use the following equipment:

A - a hydraulic drilling rig;
B - a shovel or a backhoe excavator to carry the excavated soil away from the work area;
C - a plant to produce the slurry;
D - a plant to desand the slurry;
E - a service crane to position the steel reinforcement cage in the borehole and to handle the string of pipes to cast the concrete.

Note:
Jobsite DRY / CASED (A+B+E)
Jobsite SLURRY (A+B+C+D+E)
Drilling tools

The type and configuration of drilling tools are chosen according to the nature and geomechanical characteristics of the soil to be excavated.

An auger or a bucket can be used to bore cohesionless soil or average compacted clay.

An auger consists of a central shaft with a spiral-shaped flange welded around it. The cutting edges of the helical flange have wedge-shaped teeth. Augers are suitable for digging clayey or cohesionless, dry soil. In fact, if there is ground water, the excavated soil can often fall back into the hole as the tool is being lifted out.

A bucket is made up of a hollow, cylindrical section fitted with a hatch on the bottom with a slit that is attached by a hinge to one end of the cylinder. Cutting teeth are welded onto the edge of the slit to help load the soil into the cylindrical bucket and also prevent it from falling out when the tool is withdrawn. Once the drilling tool has been brought to the surface, the hatch is unhooked from the bucket body and the soil is discharged. As it is a closed drilling tool, the bucket is ideal for digging loose, cohesionless soil or soft clay below the water table.

A rock auger or a core barrel can be used when boring highly compacted clay or rocky soil.

A rock auger uses different cutting teeth compared to a traditional auger. The teeth on a rock auger are not wedge-shaped but conical (they are also called “bullet” teeth, as they look like the streamlined tip of a bullet) with a heavy-duty metal element inserted at the top. The teeth are also housed in supports to allow them to rotate around the axle, hence wear of the cutting tip is uniform. Thanks to this configuration, rock augers are ideal for drilling highly compacted clay and soft or very weathered rocks.

When digging very hard rock formations, the most suitable drilling tool is the core barrel. A core barrel is basically a bucket without the hatch on the bottom, fitted with cutting teeth along the whole lower edge. Thanks to the special arrangement and configuration of the teeth (which can vary according to the hardness of the soil), once the rock core has entered the inner cylindrical assembly, it will not fall out as the barrel is being extracted.

Whatever the drilling tool used, it is connected to the kelly bar by a male-female coupling.

The kelly consists of a telescopic drill string (3-5 sections depending on the depth to reach) with the most external section connected to the rotary head of the hydraulic drilling rig. This system delivers the necessary rotation and thrust to the tool.
### Drilling tools

<table>
<thead>
<tr>
<th>COHESIONLESS SOIL</th>
<th>USCS (ASTM D-2487)</th>
<th>Drilling tools</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Soil description</strong></td>
<td><strong>GW</strong> 33°-45° 0 KPa</td>
<td><strong>BUCKET</strong></td>
</tr>
<tr>
<td>Clean gravel</td>
<td>Well-graded gravel and sandy gravel, little or no fine material</td>
<td>✅</td>
</tr>
<tr>
<td>Gravel &gt; 50% of coarse fraction caught in screen no. 4</td>
<td>Well-graded gravel and sandy gravel, little or no fine material</td>
<td>❌</td>
</tr>
<tr>
<td><strong>GP</strong> 30°-40° 0 KPa</td>
<td>Sandy and silty gravel, fine material &gt;12%</td>
<td>✅</td>
</tr>
<tr>
<td><strong>GM</strong> 30°-40° 0 KPa</td>
<td>Clayey gravel, fine material &gt;12%</td>
<td>✅</td>
</tr>
<tr>
<td><strong>GC</strong> 30°-40° 0 KPa</td>
<td>Clayey sand</td>
<td>✅</td>
</tr>
<tr>
<td><strong>Coarse grain soil</strong></td>
<td><strong>SW</strong> 30°-40° 0 KPa</td>
<td><strong>BUCKET</strong></td>
</tr>
<tr>
<td>Clean sand</td>
<td>Well-graded sand, from fine to coarse</td>
<td>✅</td>
</tr>
<tr>
<td><strong>SP</strong> 30°-40° 0 KPa</td>
<td>Poorly graded sand</td>
<td>✅</td>
</tr>
<tr>
<td><strong>SM</strong> 28°-35° 0 KPa</td>
<td>Silty sand</td>
<td>✅</td>
</tr>
<tr>
<td><strong>SC</strong> 28°-35° 0 KPa</td>
<td>Clayey sand</td>
<td>✅</td>
</tr>
<tr>
<td><strong>Sand &gt;=50% of coarse fraction passing through screen no. 4</strong></td>
<td><strong>ML</strong> 0-200 KPa</td>
<td><strong>BUCKET</strong></td>
</tr>
<tr>
<td>Inorganic silty, very fine sand, fine silty or clayey sand</td>
<td>✅</td>
<td>✅</td>
</tr>
<tr>
<td><strong>CL</strong> 0-300 KPa</td>
<td>Inorganic clay with medium-low plasticity, silty and sandy clay</td>
<td>✅</td>
</tr>
<tr>
<td><strong>OL</strong> 0-200 KPa</td>
<td>Organic silty and low-plasticity organic silty clay</td>
<td>✅</td>
</tr>
<tr>
<td><strong>Fine-grained soils</strong></td>
<td><strong>MH</strong> 0-20 KPa</td>
<td><strong>BUCKET</strong></td>
</tr>
<tr>
<td>Organic clay, organic silt</td>
<td>✅</td>
<td>✅</td>
</tr>
<tr>
<td><strong>CH</strong> 0-200 KPa</td>
<td>High-plasticity silt</td>
<td>✅</td>
</tr>
<tr>
<td><strong>OH</strong> 0-10 KPa</td>
<td>High-plasticity clay</td>
<td>✅</td>
</tr>
<tr>
<td><strong>Highly organic soil</strong></td>
<td><strong>Pt</strong> 0-10 KPa</td>
<td><strong>BUCKET</strong></td>
</tr>
<tr>
<td>Muskeg and other highly organic soils</td>
<td>✅</td>
<td>✅</td>
</tr>
</tbody>
</table>

Prefix: **G** = Gravel, **M** = Silt, **O** = Organic, **CL** = Clay, **HH** = Clay, LL > 50%  
Suffix: **W** = Well-graded, **P** = Poorly graded, **M** = Clayey, LL < 50 %

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### ROCKS

- **Core barrel with roller bits**
- **Core barrel with rock bits**
- **Auger with rock bits**
- **Bucket**

**Simple compressive strength (MPa)**

- 0
- 20
- 40
- 60
- 80
- 100

**Rock Quality Designation (%)**

- 0
- 20
- 40
- 50
- 70
The SR line reflects more than 45 years old of Soilmec experience in foundation technology.

A complete and assorted range, from 20 to 140 tons rigs, designed to meet the need of bored piles and really multifunctional machine, able to perform various technologies application thanks to a rapid conversion kit. The SR rigs are self-mounting, easily transportable equipment, capable to driving casing with rotary and pistons/winches or in combination with casing oscillator.

The SR rigs are equipped with the DMS (Drilling Mate System) on touch screen panel for monitoring and control of the rig performances and operating parameters.
# Evolution range

Dedicated kelly method drill rig optimally designed to give you the best drilling performance.

<table>
<thead>
<tr>
<th>EVO line - Model</th>
<th>SR-40</th>
<th>SR-60</th>
<th>SR-80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max pile diameter</td>
<td>1500 mm</td>
<td>1800 mm</td>
<td>2000 mm</td>
</tr>
<tr>
<td>Max pile depth</td>
<td>61 m</td>
<td>71 m</td>
<td>77 m</td>
</tr>
<tr>
<td>Max torque</td>
<td>161 kNm</td>
<td>201 kNm</td>
<td>271 kNm</td>
</tr>
<tr>
<td>Rated engine power</td>
<td>180 kW</td>
<td>261 kW</td>
<td>328 kW</td>
</tr>
<tr>
<td>Operative weight</td>
<td>51 t</td>
<td>66 t</td>
<td>85 t</td>
</tr>
</tbody>
</table>

# Advanced range

A flexible machine, optimized to give you the best drilling solution.

<table>
<thead>
<tr>
<th>ADV line - Model</th>
<th>SR-30</th>
<th>SR-45</th>
<th>SR-75</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max pile diameter</td>
<td>1500 mm</td>
<td>1500 (3000) mm</td>
<td>2000 (2500) mm</td>
</tr>
<tr>
<td>Max pile depth</td>
<td>48 m</td>
<td>65 m</td>
<td>76 m</td>
</tr>
<tr>
<td>Max torque</td>
<td>130 kNm</td>
<td>185 kNm</td>
<td>290 kNm</td>
</tr>
<tr>
<td>Rated engine power</td>
<td>164 kW</td>
<td>201 kW</td>
<td>328 kW</td>
</tr>
<tr>
<td>Operative weight</td>
<td>36 t</td>
<td>41 t</td>
<td>74 t</td>
</tr>
</tbody>
</table>
High technology range
A multipurpose machine, optimized to give you the best technological solution

### HIT line - Model

<table>
<thead>
<tr>
<th>HIT line - Model</th>
<th>SR-95</th>
<th>SR-125</th>
<th>SR-145</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max pile diameter</td>
<td>2100 (3000) mm</td>
<td>3000 (3500) mm</td>
<td>3000 (3500) mm</td>
</tr>
<tr>
<td>Max pile depth</td>
<td>106.5 m</td>
<td>121 m</td>
<td>121 m</td>
</tr>
<tr>
<td>Max torque</td>
<td>351 kNm</td>
<td>435 kNm</td>
<td>435 kNm</td>
</tr>
<tr>
<td>Rated engine power</td>
<td>403 kW</td>
<td>470 kW</td>
<td>470 kW</td>
</tr>
<tr>
<td>Operative weight</td>
<td>96 t</td>
<td>135 t</td>
<td>149 t</td>
</tr>
</tbody>
</table>

Crane attachment rotaries range
Mechanical and hydraulic rigs to equip your crane for large diameter bored piles

### SA & SR series

<table>
<thead>
<tr>
<th>SA &amp; SR series</th>
<th>RT3-ST</th>
<th>SA-40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max pile diameter</td>
<td>3000 mm</td>
<td>4000 mm</td>
</tr>
<tr>
<td>Max pile depth</td>
<td>78 (120) m</td>
<td>94 (106) m</td>
</tr>
<tr>
<td>Max torque</td>
<td>210 kNm</td>
<td>413 kNm</td>
</tr>
<tr>
<td>Min. crane capacity</td>
<td>40 t</td>
<td>90 t</td>
</tr>
</tbody>
</table>