TECHNOLOGY

Bored Piles

TREVI


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TREVIGroup
SCAVI

Drilling diameters
up to 4,000 mm

Drilling depth
over 100 m

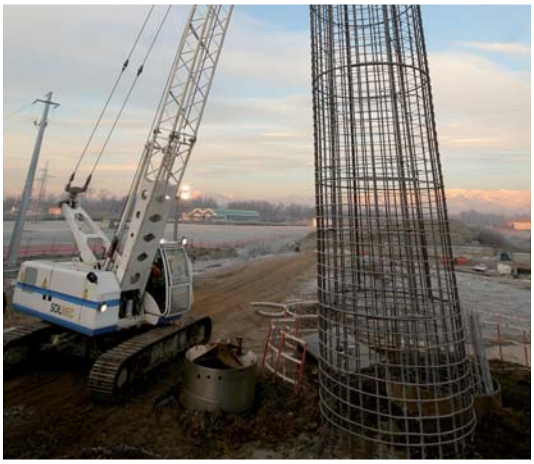
Technology

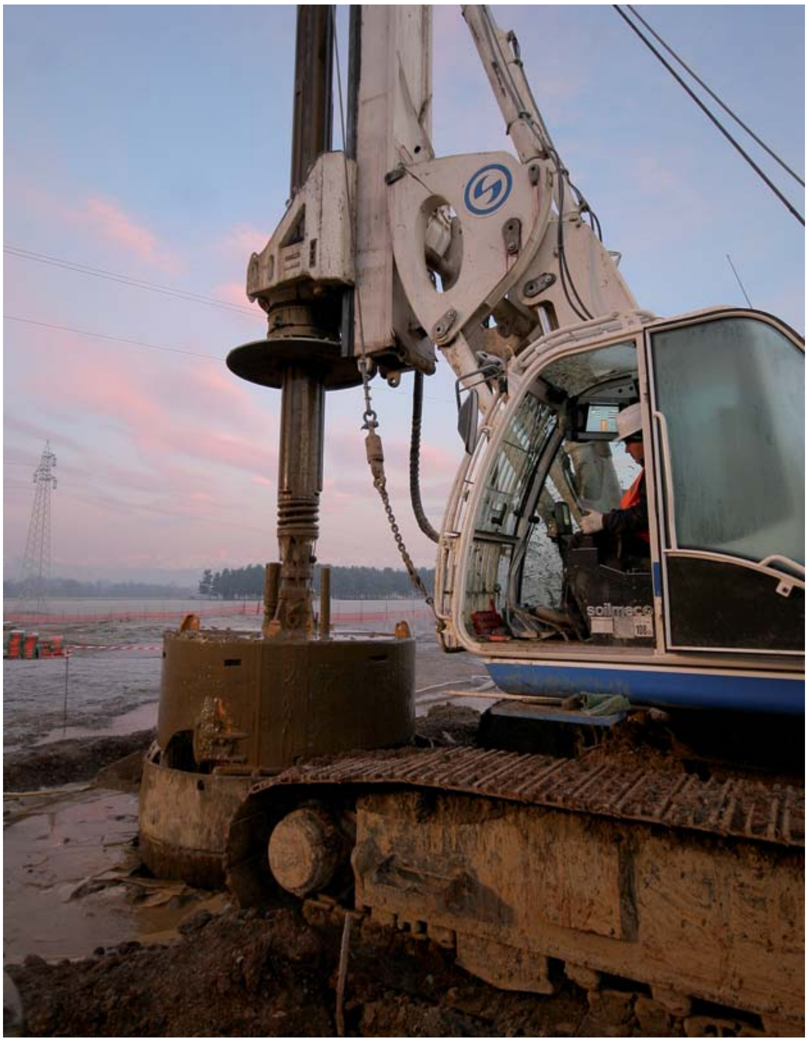
Bored piles are constructed in the following stages:

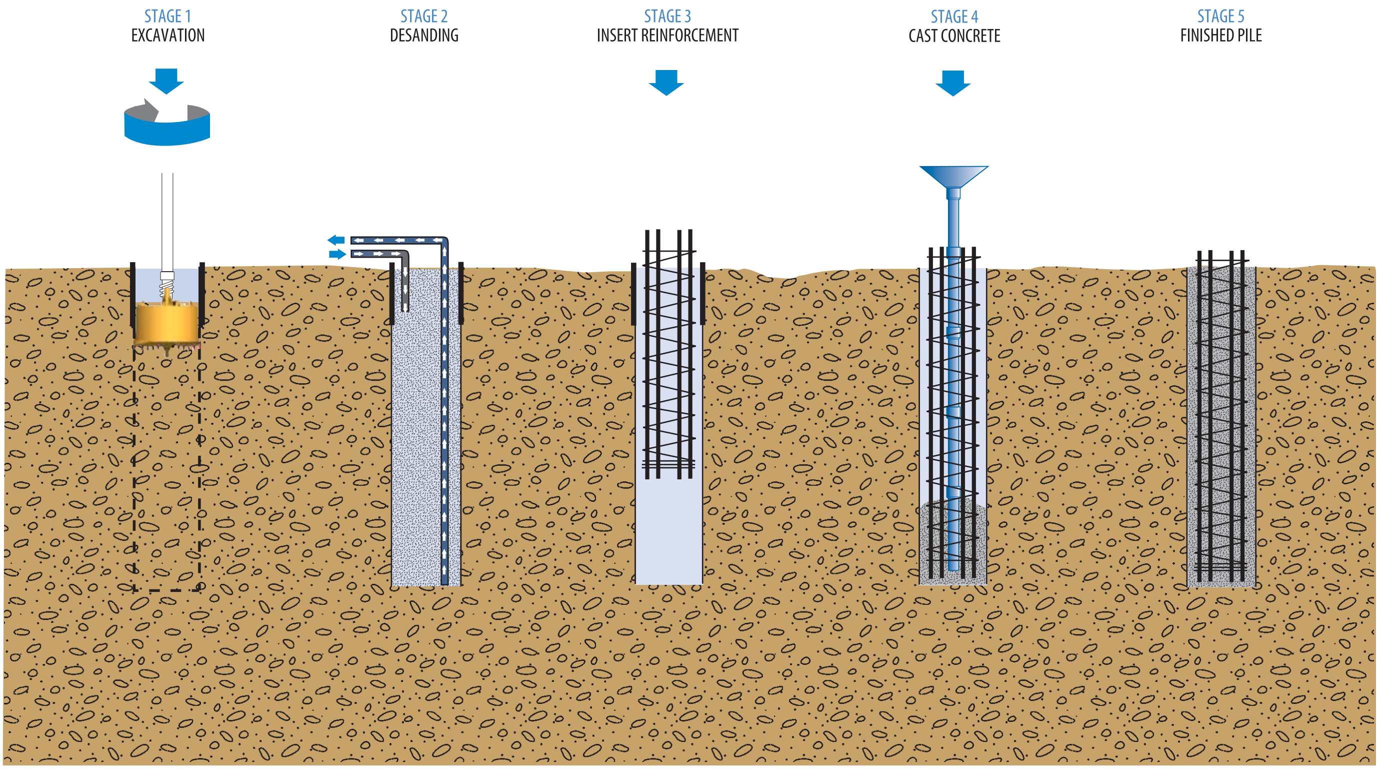
- the soil is removed using drilling tools chosen according to the particular characteristics of the ground;
- the slurry is "regenerated" by removing the coarsest material of the soil (this process is called "desanding");
- a steel reinforcement cage is inserted in the borehole;
- the borehole is filled with concrete.

To prevent the soil near the surface from collapsing, it is established practice to first insert a co-axial casing with a diameter slightly larger than the diameter of the tool. The actual length of the casing depends on the characteristics of the soil encountered in the first couple of metres of soil excavated.

This temporary casing is usually driven into the ground by using the rotary head of the drilling rig or a hydraulic vibratory hammer connected to a service crane.





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Construction stages

Drilling stages

When drilling bored piles, the operator performs cyclical operations:

• the **kelly bar**, with the drilling tool attached to the base, is lowered and the tool is aligned with the axis of the pile to be constructed;

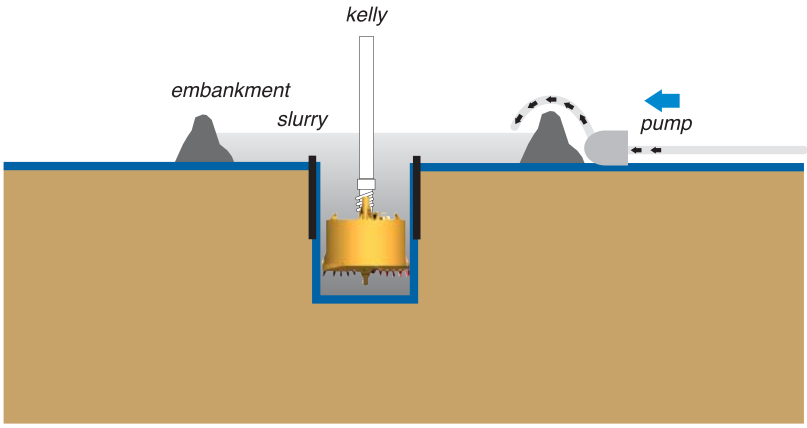
• the **hole** is excavated by rotation and thrust;

• the **drilling tool** is brought back to the surface;

• the **drilling rig** turret is rotated into position to discharge the soil;

• the soil in the drilling tool is discharged (either directly onto the ground or into a truck);

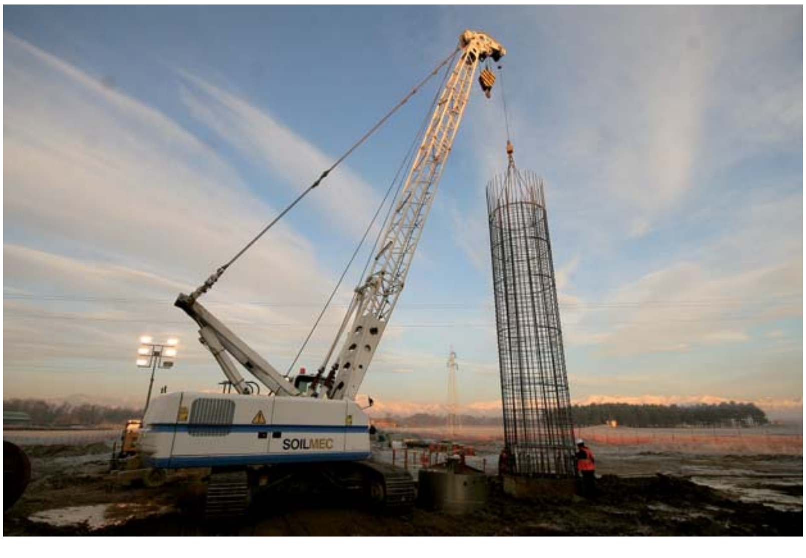
• the turret is rotated and the tool realigned to the pile axis.



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 one metre above the water table, help make the shaft watertight, preventing the walls from collapsing.
On smaller jobsites, the level of slurry can be kept constant by simply building a retaining basin with soil embankments around the borehole and adding more slurry as the hole gets deeper and deeper.
To avoid excessive use of slurry and keep the working

Construction stages



area in optimal conditions, it is a good idea to let all the slurry in the drilling tool “drip” out when the latter is withdrawn from the hole before discharging the soil.

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”.

Inserting the reinforcement cage

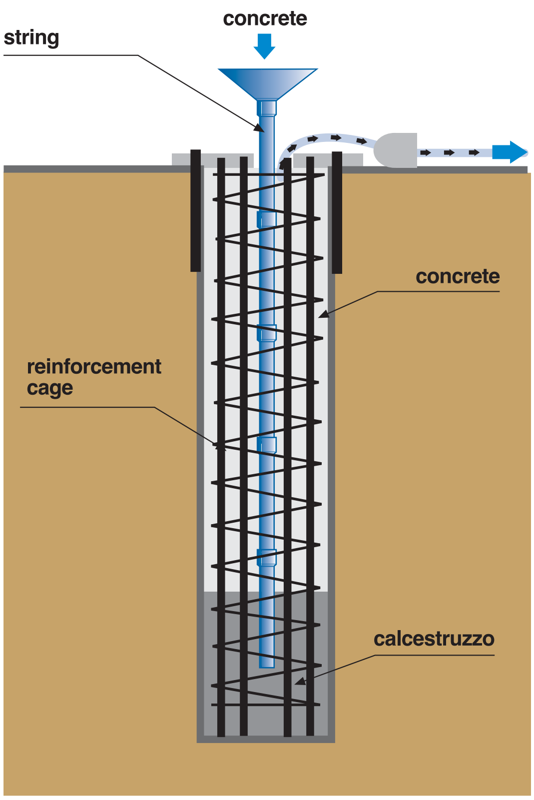
Immediately after the desanding of the slurry and the final control of the rheological properties, the steel reinforcement cage is inserted in the shaft using a service crane of a suitable capacity. As it is being lowered, special concrete or plastic spacers are applied to the outside of the cage to ensure the established bond length at the sides is respected.
In order to guarantee sufficient bond length 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 2î iron pipes on the inside to carry out non-destructive sonic tests.

Construction stages

Casting the concrete

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

To do this, a string of iron 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.



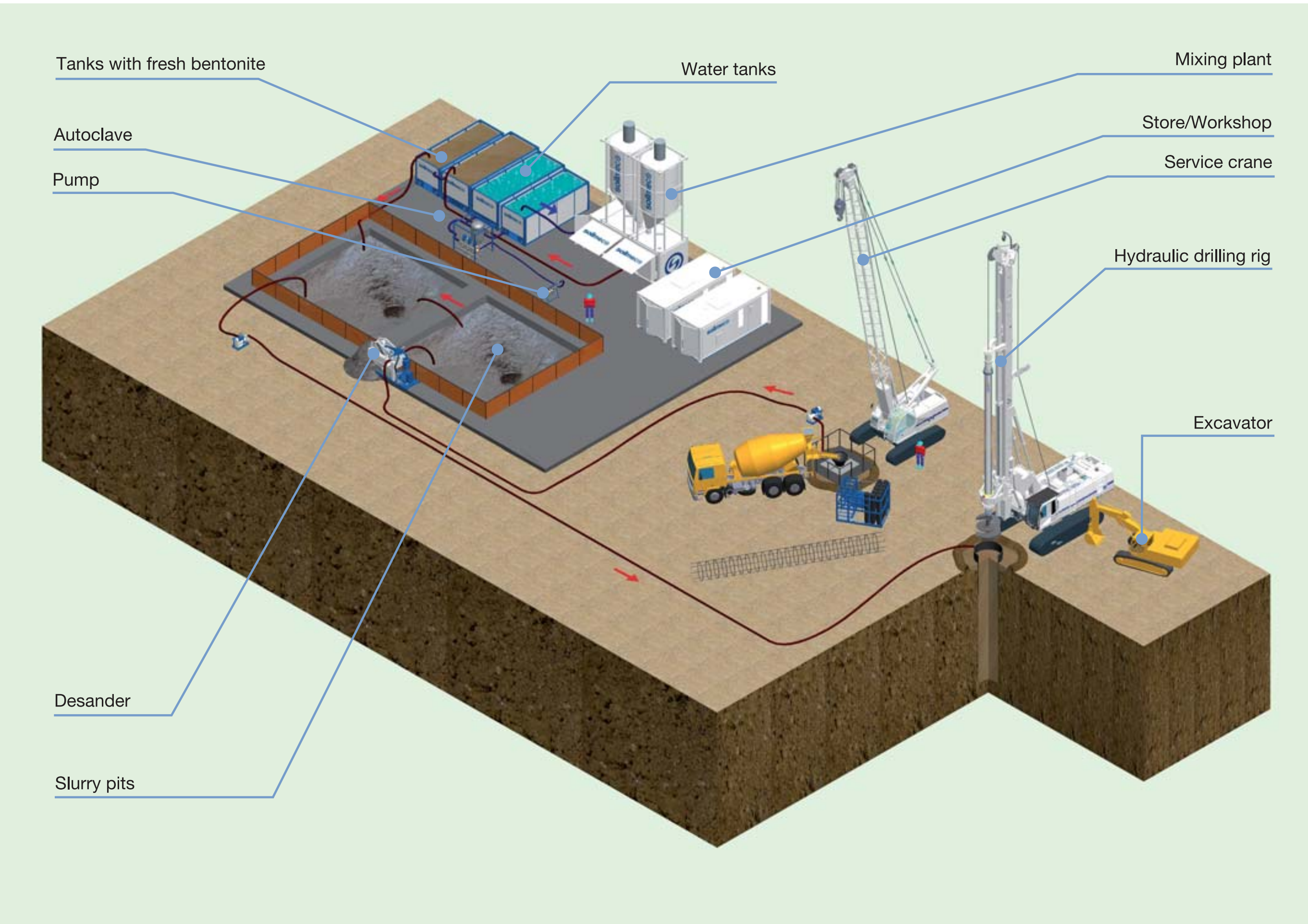
The concrete flows down the pipes and , when it reaches the bottom, it begins to fill the hole, rising back up. Thanks to the considerable difference in density between the two fluids, the slurry does not mix with the concrete but is forced up towards the surface where it is collected in special slurry 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.

On-site logistics

A typical jobsite constructing bored piles through slurries will use the following equipment:

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



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.

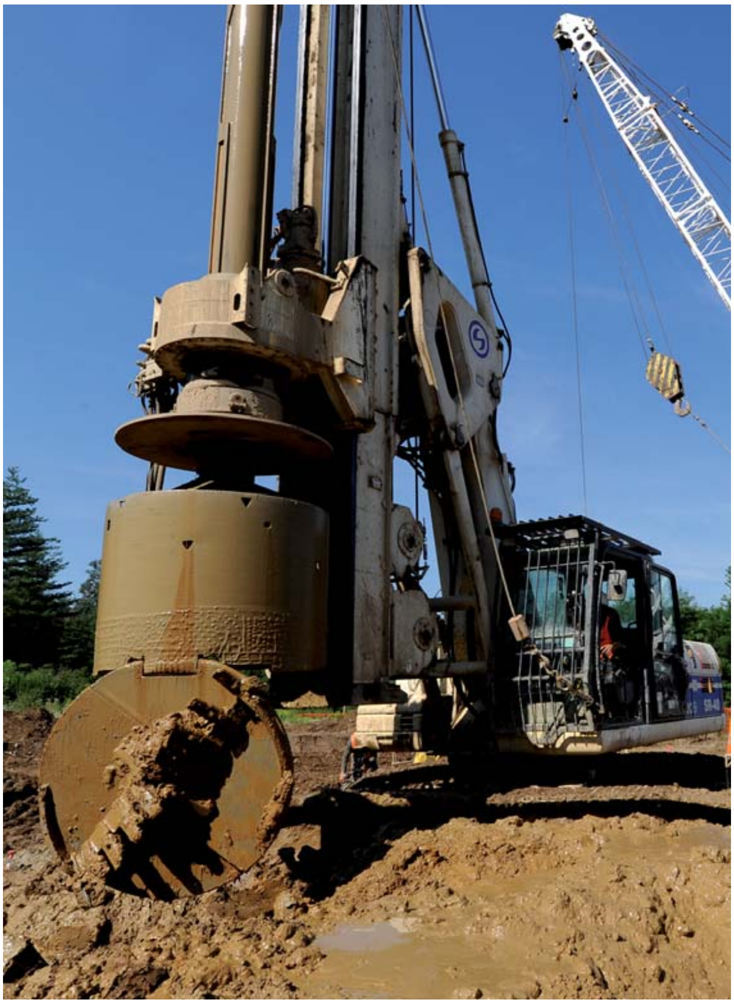
A rock auger or a core barrel can be used when boring highly compacted clay or rocky soil.

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.

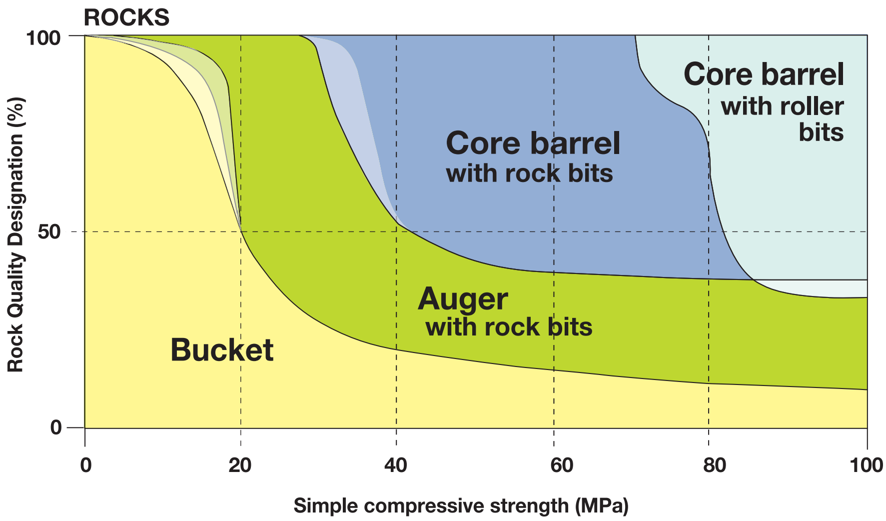
When digging very hard rock formations, the most suitable drilling tool is the core barrel. A core barrel is basically a bucket without the hatch on the bottom, fitted with cutting teeth along the whole lower edge. Thanks to the special arrangement and configuration of the teeth (which can vary according 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



COHESIONLESS SOIL

USCS (ASTM D-2487) Soil description						Drilling tools: BUCKET	Drilling tools: AUGER
Coarse grain soil	Gravel > 50% of coarse fraction caught in screen no. 4	Clean gravel	GW	33°-45° 0 KPa	Well-graduated gravel and sandy gravel, little or no fine material	☑	☐
Coarse grain soil	Gravel > 50% of coarse fraction caught in screen no. 4	Clean gravel	GP	33°-45° 0 kPa	Well-graduated gravel and sandy gravel, little or no fine material	☑	☐
Coarse grain soil	Gravel > 50% of coarse fraction caught in screen no. 4	Gravel with fine material	GM	30°-40° 0 KPa	Sandy and silty gravel, fine material >12%	☑	☐
Coarse grain soil	Gravel > 50% of coarse fraction caught in screen no. 4	Gravel with fine material	GC	30°-40° 0 KPa	Clayey gravel, fine material >12%	☑	☐
Coarse grain soil	Sand >=50% of coarse fraction passing through screen no. 4	Clean sand	SW	30°-40° 0 KPa	Well-graduated sand, from fine to coarse	☑	☐
Coarse grain soil	Sand >=50% of coarse fraction passing through screen no. 4	Clean sand	SP	30°-40° 0 KPa	Poorly graduated sand	☑	☐
Coarse grain soil	Sand >=50% of coarse fraction passing through screen no. 4	Sand with fine material	SM	28°-35° 0 KPa	Silty sand	☑	☑
Coarse grain soil	Sand >=50% of coarse fraction passing through screen no. 4	Sand with fine material	SC	28°-35° 0 KPa	Clayey sand	☑	☑
Terreni a grana fine	Silt and clay Liquid limit (LL)<50		ML	0-200 KPa	Inorganic silt, very fine sand, fine silty or clayey sand	☑	☑
Terreni a grana fine	Silt and clay Liquid limit (LL)<50		CL	0-300 KPa	Inorganic clay with medium-low plasticity, silty and sandy clay	☑	☑
Terreni a grana fine	Silt and clay Liquid limit (LL)<50		OL	0-200 KPa	Organic silt and low-plasticity organic silty clay	☑	☑
Terreni a grana fine	Silt and clay Liquid limit (LL)<50		MH	0-20 KPa	High-plasticity silt	☑	☑
Terreni a grana fine	Silt and clay Liquid limit (LL)<50		CH	0-200 KPa	High-plasticity clay	☑	☑
Terreni a grana fine	Silt and clay Liquid limit (LL)<50		OH	0-10 KPa	Organic clay, organic silt	☑	☑
	Highly organic soil		Pt	0-10 KPa	Muskeg and other highly organic soils	☑	☑

Prefix
G = Gravel **M** = Silt **O** = Organic
S = Sand **C** = Clay **H** = Clay, LL > 50%

Suffix:
W = Well-graduated **M** = Silty
P = Poorly graduated **L** = Clayey, LL < 50 %

World leader in ground engineering, Trevi has been working for more than 50 years throughout the world, strengthening its ability to provide solutions to any ground engineering issues. Trevi works in the field of special foundations, soil consolidation, dam remedial works, tunnel construction and consolidation, marine works, rehabilitation and clean-up of contaminated sites and construction of underground automatic multi-storey car parks.
Trevi is committed to continuous innovation and searching for solutions to complex civil engineering problems worldwide. Experimenting cutting-edge technologies, entrepreneurship and investing in research and human resources are the strengths of a company based in more than 30 countries.

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