



TECHNOLOGY

# Jet Grouting

**soilmeco**  
Drilling and Foundation Equipment



Jet grouting improves soil mechanical and permeability properties by using high-speed jets of water/cement mixtures injection treatment.

Jet grouting can be advantageoudly in the following conditions:

- difficult logistic conditions
- confined spaces
- presence of obstacles to cross
- high-depth treatment with crossing of voids


### **Suitable soils**

The jet grouting technique allows to improve a wide range of soil types. As it is based on soil erosion, soil erodibility is crucial to the final result.

The more consistent the soil to be treated, the smaller the column diameter. Therefore, larger columns can be obtained in loose soft soils and smaller ones in cohesive soils.





A photograph of a construction site. In the foreground, two workers wearing orange high-visibility safety suits and hard hats (one blue, one white) are looking towards a large drilling rig. The rig is a yellow and white machine with a long vertical mast. The background shows a line of green trees under a clear blue sky. Three green text boxes are overlaid on the right side of the image, containing descriptive text about the rig's capabilities.

Capability to obtain columns of consolidated soil with diameter ranging from 60 to more than 300 cm by using small diameter drilled holes, in general not larger than 180÷200 mm.

Capability to overpass pre-existing foundations, boulders, rocky layers.

Use of light weight and small-sized drill rigs in small working areas



# Technology

Consolidated elements – usually columns – are constructed using small-diameter drilling (100 to 140 mm), by means of light and easy to handle rigs.

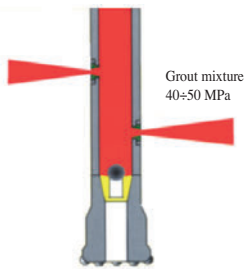
Moreover this technology allows to realize consolidated soil elements and overcome underground obstacles (foundations, blocks, etc.).

Jet grouting is usually performed down to depths of 20-30 m. However, special projects reaching 100 m-depth have also been realized.

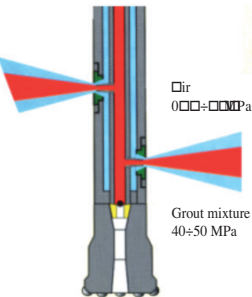
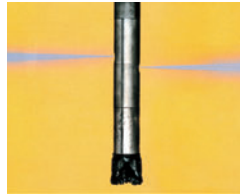




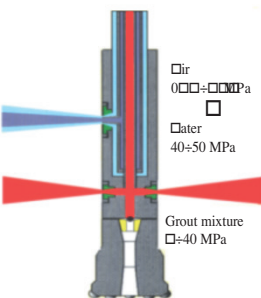
# Construction stages



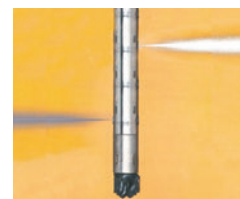
**Trevijet T1**  
Monofluid



**Trevijet T1**  
Bifluid



**Trevijet T1**  
Triple fluid



All jet grouting techniques envisage a preliminary phase of drilling, followed by extraction and rotation at preset values, and simultaneous pumping of the fluids at high pressure.

Depending on the number of fluids used, the European standard EN 12716 has identified three main techniques:

- **Monofluid (TREVJET T1)**: a water/cement mixture is injected to break up and simultaneously mix the soil in-situ. Diameters usually range from 0.4 to 1 m.

- **Bifluid (TREVJET T1/S)**: a combination of water/cement mix and air is injected to break up and simultaneously mix the soil in-situ. Diameters usually range from 0.8 to 2.5 m.

- **Triple fluid (TREVJET T2)**: a combined water/air jet is used to break up and partially remove the soil in-situ, whereas soil mixing is ensured by a lower water/cement injection.

Before starting to work, the position of each drilling point (distance between the centres and from the reference points) must be determined and staked out on the ground, or marked by means of a satellite positioning system. The treatment parameters are chosen only after conducting preliminary field tests.

In case of very cohesive soils, the pre-cutting technique may be used. It consists in a pre-treatment with water under pressure which is conducted during extraction or drilling. The grout must be injected immediately after drilling, by extracting and rotating the string at pre-set and constant raising and rotation speeds while pumping the cement mixture at high pressure.

The injection mixtures generally consist of water and cement; additives and bentonite can be added to stabilize them.

The mixture standard composition is the following (for 1 m<sup>3</sup>):

- cement (kg) 500 ÷ 1100
- water (l) 650 ÷ 800
- bentonite or fluidifying agents (kg) 0 ÷ 14

If required by the project, a reinforcement tube or H-beam can be installed through the mixed soil, at the end of the treatment. Sometimes re-drilling is necessary to place the reinforcement element.

During treatment, any excess fluid is evacuated to the surface (commonly named drain). Although it may seem a waste of material, the lack of it could actually indicate an ineffective treatment.

**STAGE 1**  
Drilling



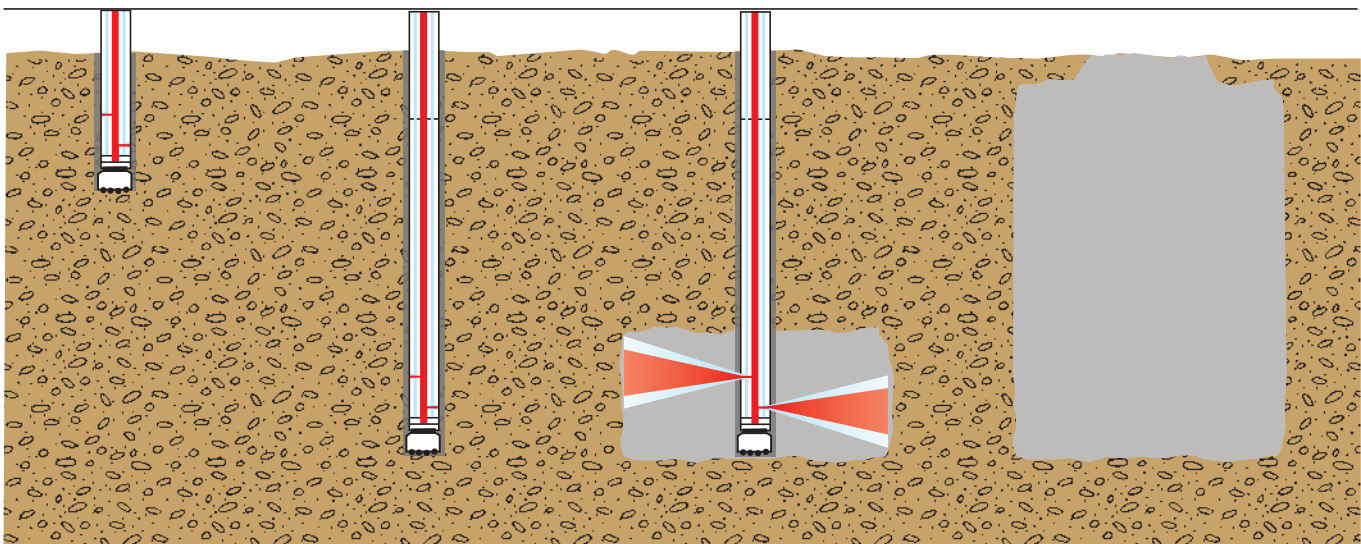
**STAGE 2**  
Drilling completion



**STAGE 3**  
With drawal and  
rotation with injection



**STAGE 4**  
Completed column



# Innovation

## ETJ (Enhanced Trevijet)

TREVI has recently designed and patented a new high-efficiency monitor (ETJ = Enhanced Trevi Jet). The ETJ system includes a cutting-edge monitor and standard jobsite equipment for jet grouting (mixing systems, pumps, drilling rigs, jetting rods). The monitor is fitted with two curvilinear conduits that reduce head losses caused by any sudden variation of the fluid direction (from axial in the rods to radial through the nozzles). In this way, the jet is extremely consistent and allows to significantly improve jet grouting efficiency, and to obtain column diameters larger than the ones realized using standard methods.

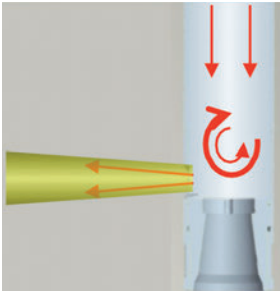
The ETJ system can be used for both monofluid and bifluid treatments.

### Increased efficiency

Monofluid	Diameter variation	25-50%
Monofluid	Treated volume	60-100%
Bifluid	Diameter variation	15-20%
Bifluid	Treated volume	25-40%



## TRADITIONAL monitor



## ETJ monitor





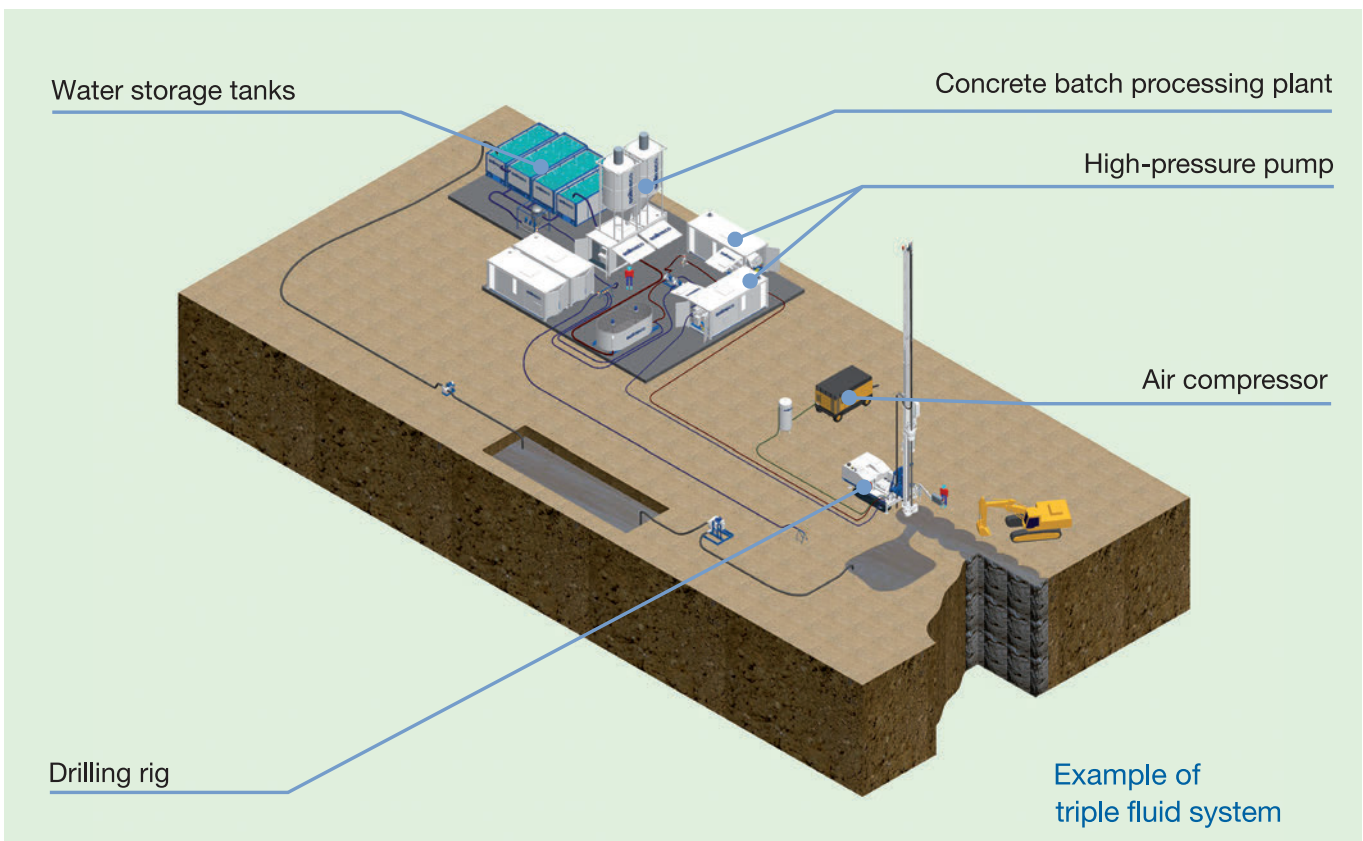
# Logistics



The equipment needed for jet grouting are the following: drilling rigs, concrete batch processing plants, high pressure pumps, compressors. The type and number of equipment depend on the technique used.

Installed power ranges from min. 600 HP (monofluid) to max roughly 1000 HP (triple fluid).

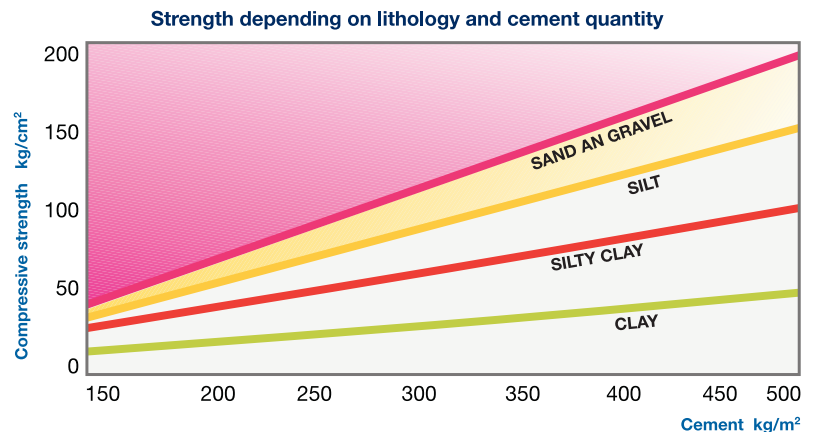
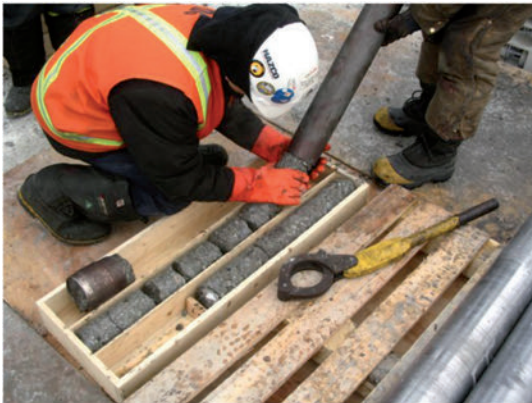
Method	Installed power
TREVIJET T1	HP 600 ÷ 700
TREVIJET T1/S	HP 700 ÷ 800
TREVIJET T2	HP 850 ÷ 1000



# Properties of consolidated soils

The physical and mechanical properties of consolidated soils mainly depend on the type and composition of the soil itself, as well as on the cement quantity which remains in the ground. Unconfined compressive strength values of 6÷15 MPa can be obtained in coarse alluvial soil, whereas strength is considerably reduced in the presence of cohesive lithotypes.

Average soil permeability values range from 10-6 to 10-7 m/sec.



The physical-mechanical characteristics of the treated soils depend mainly on the nature and composition of the soil itself, and on the quantity of cement remaining in the soil. In the chart here, is shown the strength of various type of treated soils as a function of the quantity of cement actually incorporated in the final product. In the chart it is evident as values of unconfined compressive strength (UCS) of 6 to 15 MPa can be achieved in coarse alluvial soils, whereas in cohesive lithologies the strength is sensibly lower.

## Quality controls

The jet grouting technology is intended to create underground consolidated elements and, as a result, it is often impossible to directly check the quality of the final product. However, quality control is crucial for some works.

Given the wide range of different soils in which jet grouting is carried out, it is always recommended to realize a test field in order to calibrate the operating parameters and obtain the expected results.

### DMS (Drilling Mate System)

During the construction of columns in-situ, it is advisable to use an automatic device to record the parameters and use the ones defined in the test field. In this way, a document is created for each column, which describes the operating method.

The DMS is a recording system that can be assembled on any drilling rig. It consists of an automatic device that records and checks the drilling and treatment parameters, ensuring high quality standards.

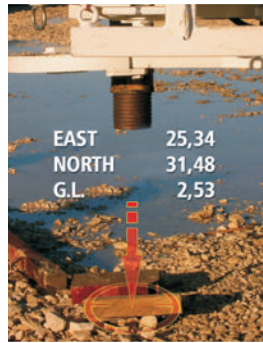
The operator can set the parameters by means of a touch screen.

The device can also be interfaced with a number of instruments and accessories to measure verticality and help the operator position the machine.





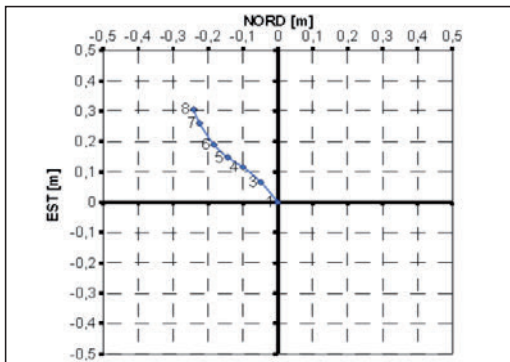
DPS display



### DPS JET (Drilling Positioning System)

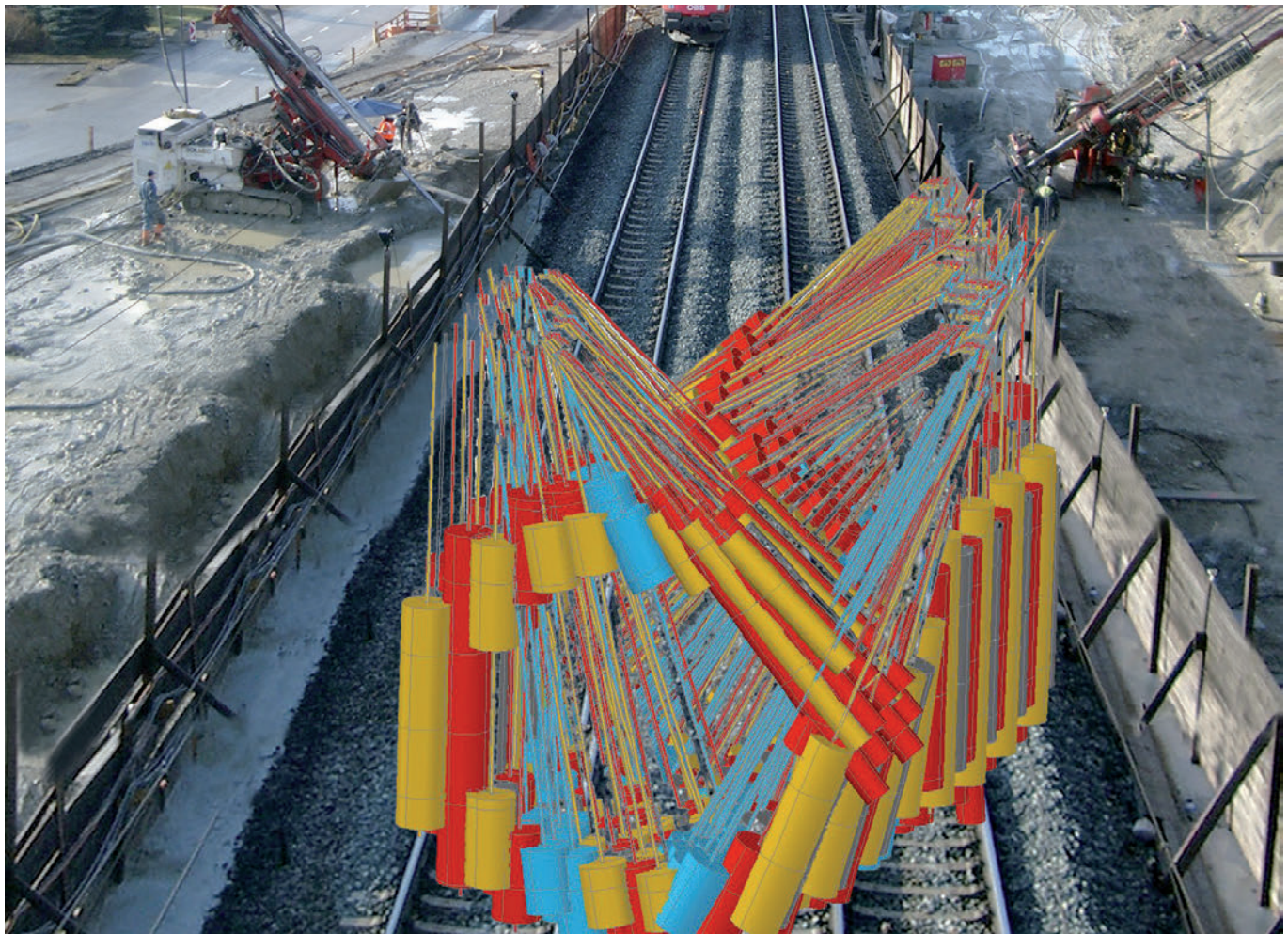
The DPS has been developed to control the position of monofluid and bifluid jet grouting columns. The device allows to make measurements within an area of  $\pm 60$  degrees from the vertical. This control is extremely important in the execution of bottom plugs and deep waterproofing shields. The DPS provides inclination and direction data, the standard deviation value of each of the abovementioned measurements, the deviations calculated in North-East and polar coordinates for each stop and the stop heights.

APS polar chart



### APS (Automatic Positioning System)

The APS is a GPS-guiding system capable of integrating in real time the topographic position coordinates and the drilling parameters for each equipment used in the jobsite. When positioning the drilling rig, the operator is guided towards the drilling point by the indications on the display. Moreover the operator can check every function from a display installed onboard the drilling rig. This device allows to improve quality control, by recording the precise initial and final height of each column, and saving the already treated points.



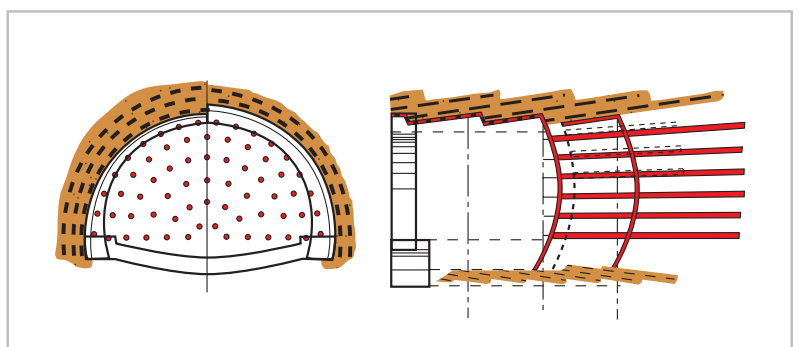
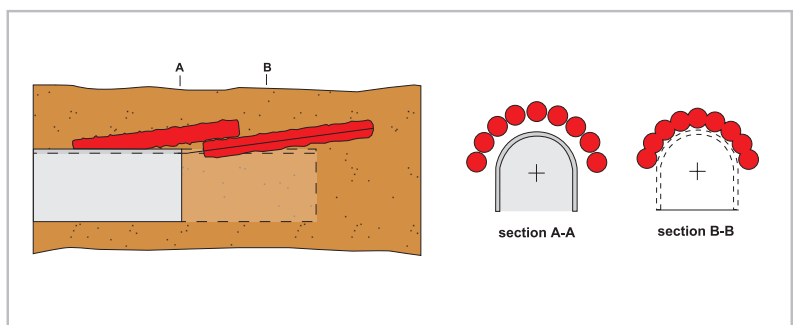
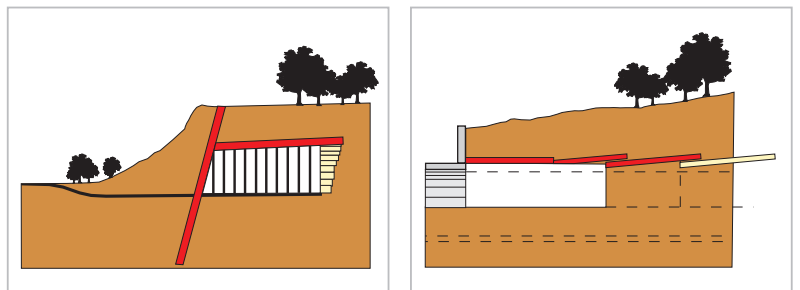
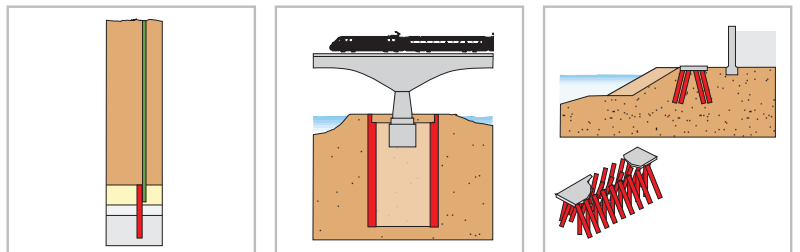
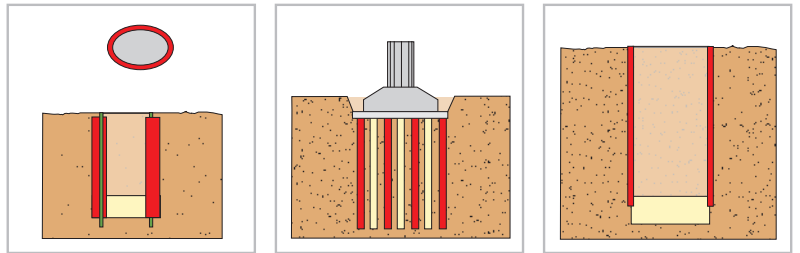
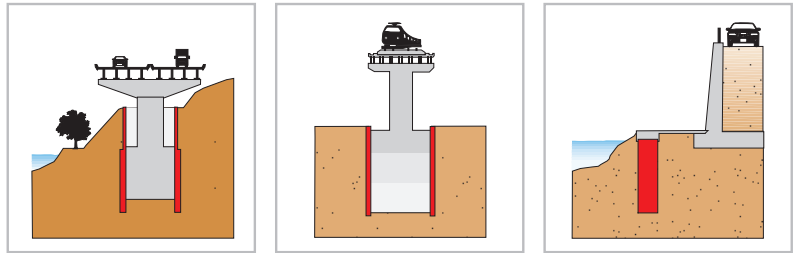


# Applications

The jet grouting technique is suitable for a number of applications, when other techniques cannot be used.

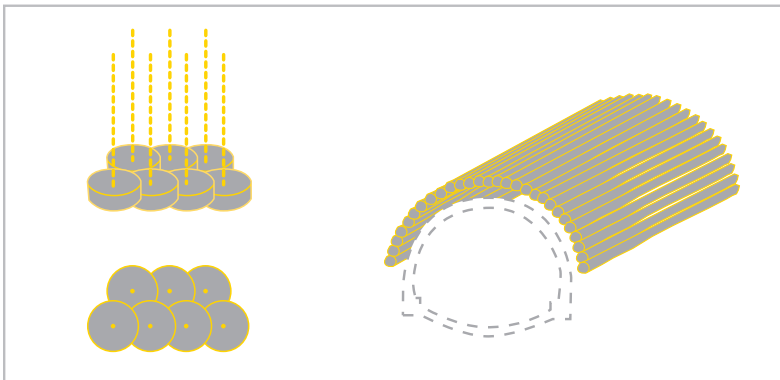
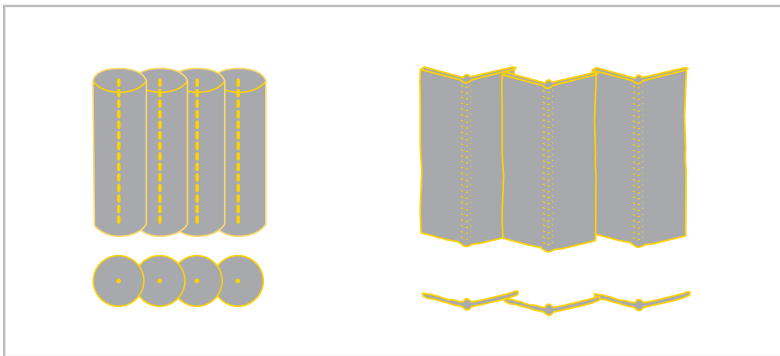
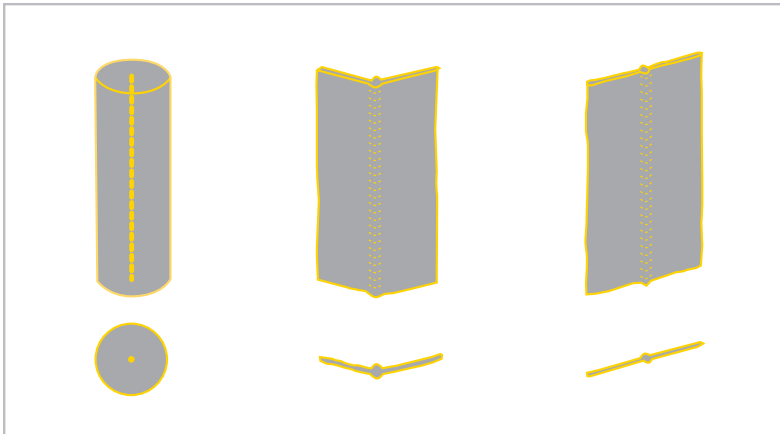
In particular, the following applications can be mentioned:

- **Consolidation of existing foundations**
- **Reduction in subsidence for new structures**
- **Retaining walls for excavation protection**
- **Waterproof curtain walls** (horizontal and vertical)
- **Preliminary consolidation works** (from the interior or exterior) for tunnelling.





# Shapes



The common shapes of jet grouting treatments are cylindrical columns that are obtained by keeping constant rotating and raising speeds, or thin layers, which are constructed at a constant raising speed, without rotating the string.

Other shapes can also be obtained by modifying the rotation speed, to realize cylindrical sectors.



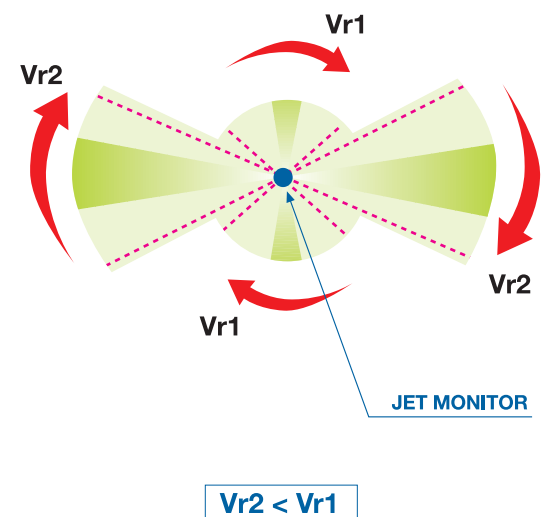
## EJG (Elliptical Jet Grouting)

TREVI has patented an innovative technique which allows to realize pseudo-elliptical columns.

This geometry is obtained by modifying the rotation speed in a planned way. It allows to maximize the use of jet grouting columns when the treatment is aimed at constructing a curtain wall, thus ensuring significant time and material savings.

### Operating principle for the construction of elliptical columns

The rotation speed varies from  $Vr1$  to  $Vr2$  to create variable radius sectors.





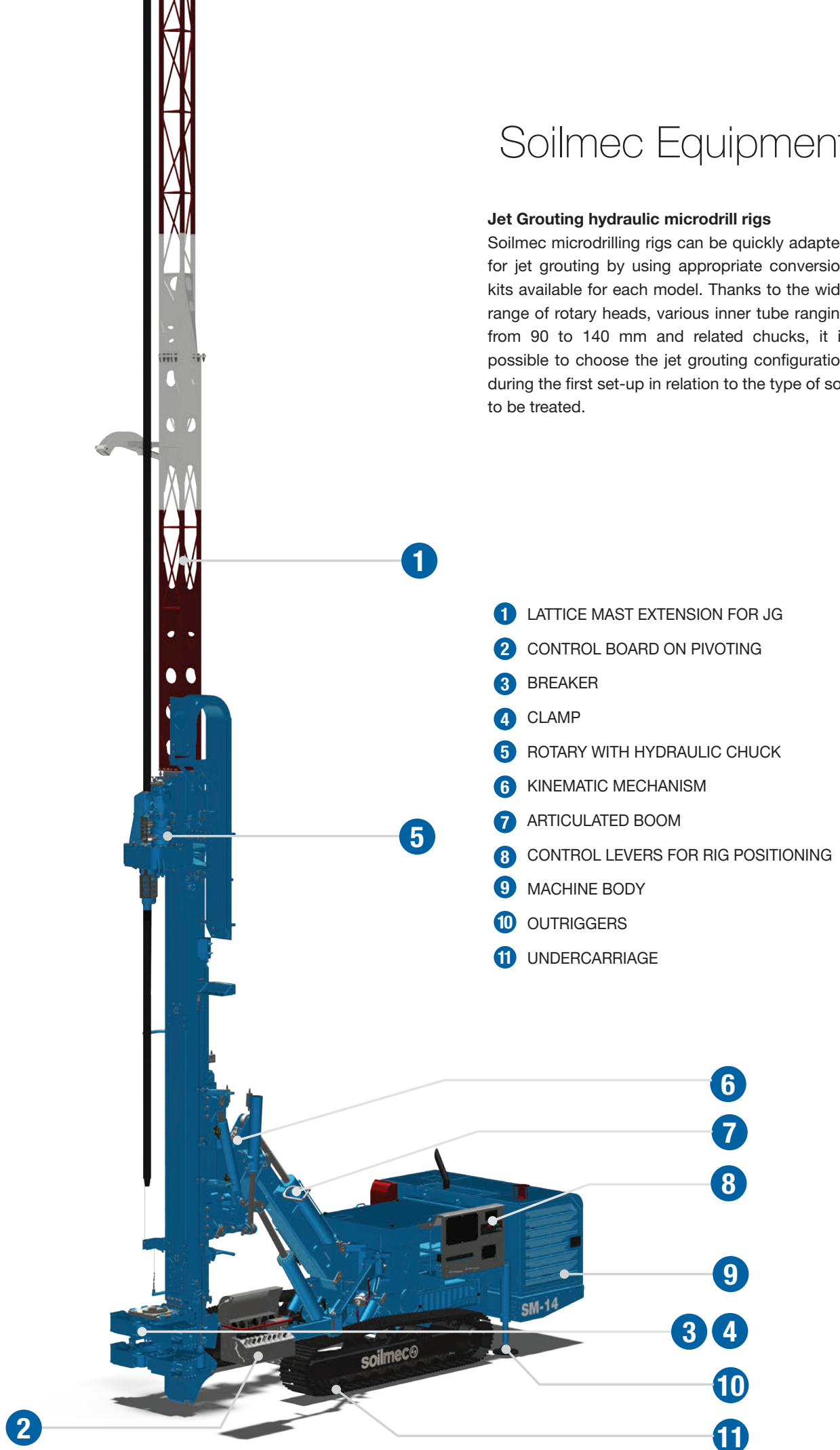




# Soilmec Equipment

## Jet Grouting hydraulic microdrill rigs

Soilmec microdrilling rigs can be quickly adapted for jet grouting by using appropriate conversion kits available for each model. Thanks to the wide range of rotary heads, various inner tube ranging from 90 to 140 mm and related chucks, it is possible to choose the jet grouting configuration during the first set-up in relation to the type of soil to be treated.





# Soilmec Equipment

## SM series

Hydraulic drilling rig designed to perform:  
micropiles, anchors, top hammer,  
vibratory, water wells, soil investigation  
and consolidations with jet grouting



Model	SM-5	SM-9	SM-10	SM-14	SM-17
Rated engine power	71 kW	105 kW	116 kW	119 kW	160 kW
Max torque	920 daNm	1700 daNm	1360 daNm	2083 daNm	3660 daNm
Max hoist	50 kN	60 kN	80 kN	89 kN	145 kN
Weight	5,5 t	9,5 t	12,5 t	15 t	19 t
JG single pass treatment	7 m	12 m	12 m	18,1 m	20 m



# Soilmec Equipment



 SM-18



 SM-21



 SM-22



 SM-28

Model	SM-18	SM-21	SM-22	SM-28
Rated engine power	176 kW	176 kW	201 kW	194 kW
Max torque	3660 daNm	3660 daNm	4200 daNm	4500 daNm
Max hoist	113 kN	140 kN	100 kN	175 kN
Weight	19,5 t	21,6 t	22,5 t	37 t
JG single pass treatment	20 m	20 m	24 m	34 m





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