TECHNOLOGY

Hydromill

TREVI

The construction of diaphragm walls by hydromill allows the construction of panels with max deviation from the vertical of about 0.2 - 0.5%, at depths beyond 200 m. With this technology, it is possible soil layers and excavate diaphragm walls in bedrocks with compressive strength – UCS – up to 60-80 MPa.
The hydromill also allows to correct any deviation from the vertical while excavating, in order cut competent.

The special diaphragm wall construction sequence by hydromill and primary-secondary panels overlapping ensure higher chances of watertight joints than conventional grabs.

With the hydromill technology it is possible to excavate diaphragms of a thickness of more than 2,000 mm at a depth exceeding 100-150 m.

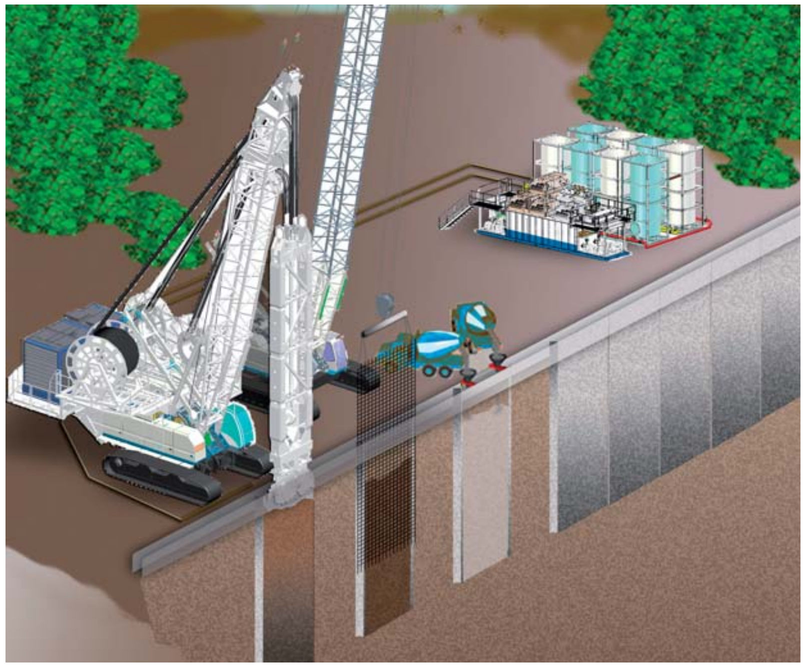
Technology

The diaphragm wall construction phases by hydromill are the following:

- **site preparation**
- **construction of guide walls**
- **pre-trench excavation**
- **panel excavation**
- **slurry de-sanding**
- **installation of reinforcement cage**
- **concreting**

The panels are divided into PRIMARY and SECONDARY panels.

The PRIMARY panels can be realized by either single or multiple bites, as shown in the scheme below.



PRIMARY PANELS

PHASE 1
PRE-TRENCH

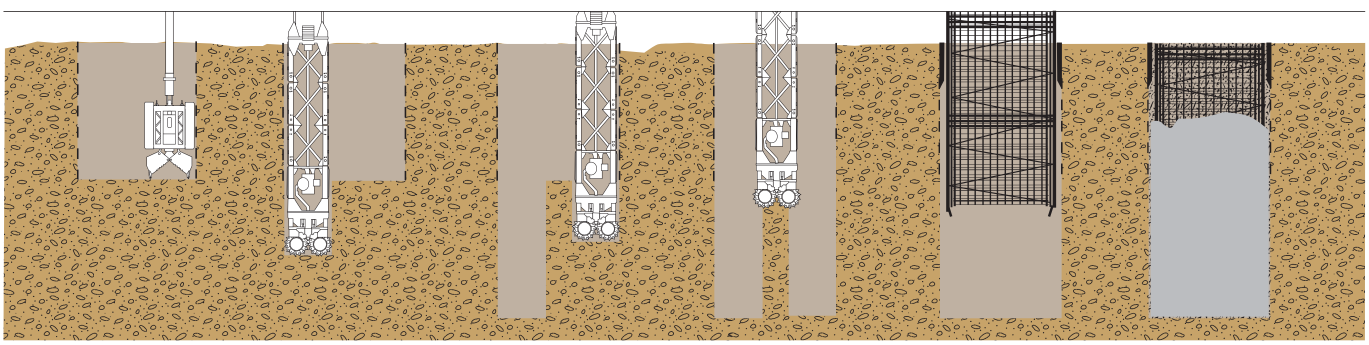
PHASE 2
1st BITE

PHASE 3
2nd BITE

PHASE 4
INTERMEDIATE BITE

PHASE 5
CAGE INSTALLATION

PHASE 6
CONCRETING



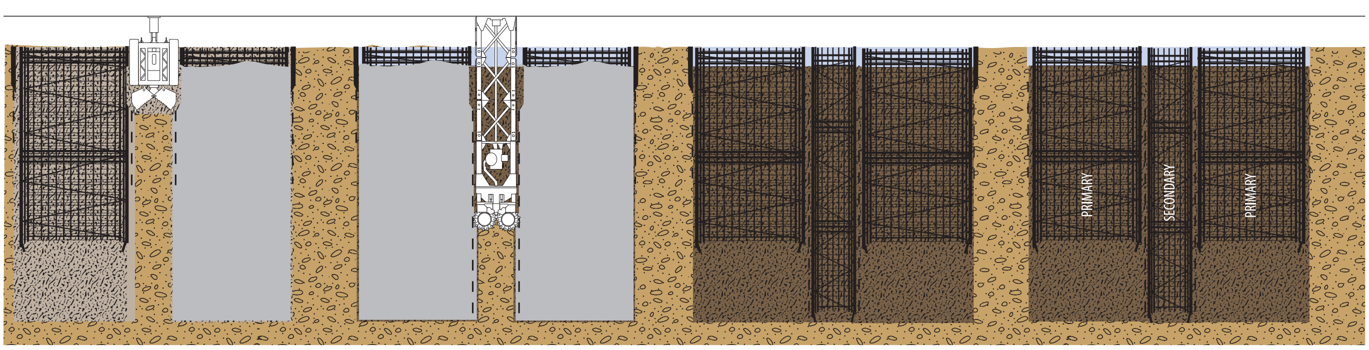
SECONDARY PANELS

PHASE 7
PRE-EXCAVATION

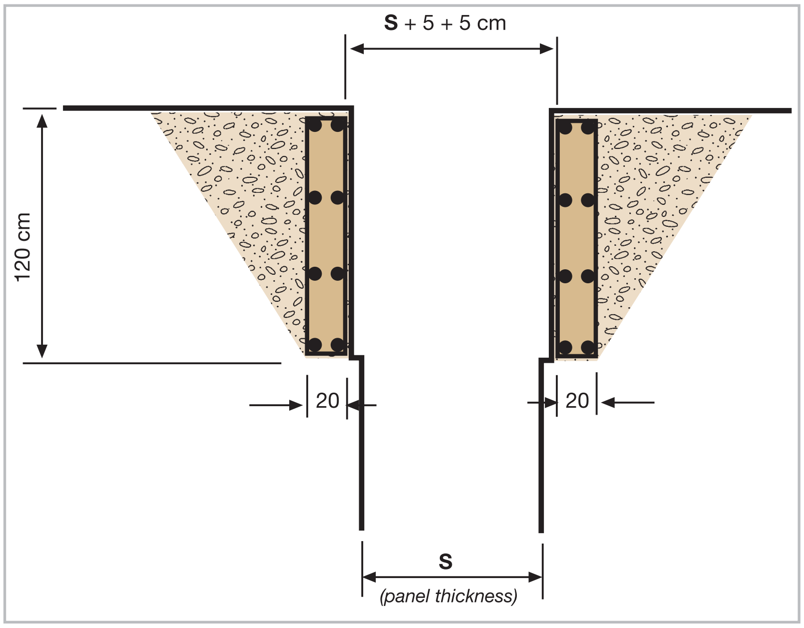
PHASE 8
EXCAVATION

PHASE 9
CAGE INSTALLATION

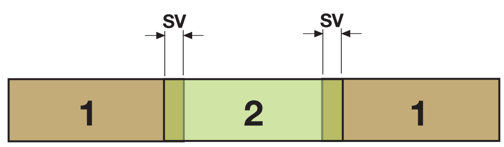
PHASE 10
CONCRETING

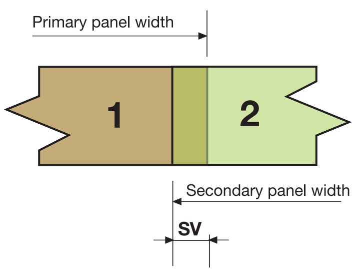


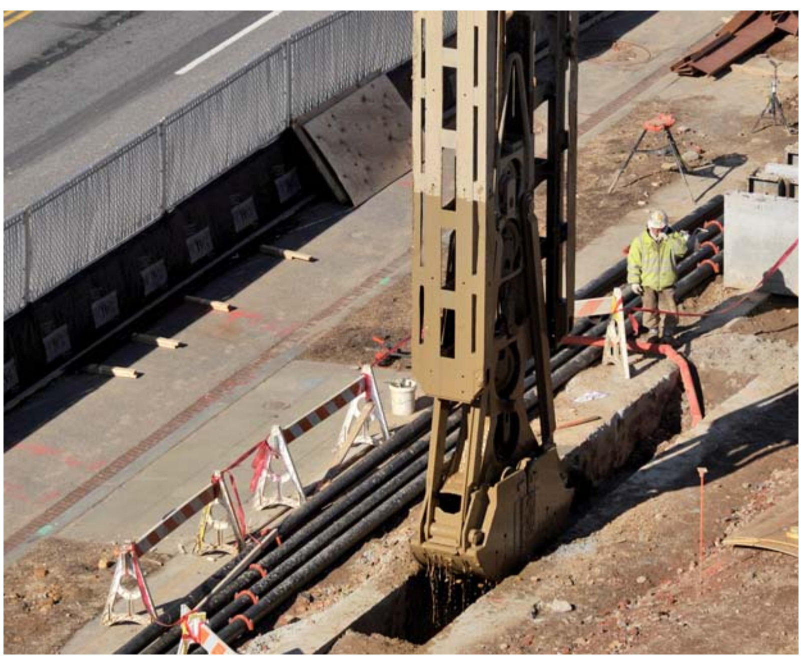
Execution phases



SV = concrete overcut in the primary panel when excavating the secondary panel







Site preparation and guide wall construction operations are similar to the ones usually carried out when excavating a diaphragm wall by conventional grab.
The work area must have bearing capacity of suitable for the construction equipment. The guide walls can be schematically realized as shown in the figure.

Guide walls

Guide walls are needed to ensure:

- a guide for the excavation and proper alignment of panels;
- the stability of the top of the trench;
- a support to the vertical loads generated by the reinforcement cages hanging above the guide wall.

Pre-trench excavation

The suction feeding pump of the hydromill is positioned above the milling drums.
It shall be fully submerged in the slurry for suction to activate. This is why a pre-trench is excavated for a few metres, to ensure the pump above the milling drums is submerged.
Pre-trench excavation is usually performed with slurries by means of a backhoe or cable grab mounted on another carrier.

Excavation

During excavation, the two milling drums should work on the same type of material as much as possible, whether natural soil or concrete.
The **primary panels** are excavated in natural soil; then the intermediate or closing **secondary** panels are excavated between two primary panels in which concreting has already been performed.
The standard width of a panel is 2.8 m,.
When soil conditions and/or wall geometry allow for it, it is possible to realize longer primary panels in three consecutive "steps" - *i.e. three excavations: left from 2.8 m; right from 2.8 m; central from 0.5 to 1.5 m; as a result, the total width of the primary panel is 6.1 or 8 m*.
The joints between panels are made of concrete to ensure higher water-tightness compared to the ones realized with grabs.
While excavating the secondary panels, the milling drums cut a small portion of concrete on each adjacent primary panel, thus creating a rough and clean contact surface at the ends of the primary panels.
The overlap on the primary panel is determined according to the depth to reach and estimated max deviations.
An auxiliary crane is used to position the reinforcement cage into the trench filled with slurry. The cage must be suitably reinforced to avoid any deformations and fitted with spacers on the faces to ensure the designed concrete cover to reinforcement.

Execution phases

Cage installation

Properly positioning the reinforcement cage is crucial to avoid that they are affected when cutting part of the primary panels.
To guide cage positioning, it is possible to use stop ends at the edges of the primary panel.

In the event two cages have to be positioned in the same panel, it is possible to use a temporary template in the middle of the panel for improved accuracy in cage positioning.
These elements will be removed during concreting.

Concreting

Concreting is performed by the “Tremie” method, using pipes of a length of about 2 m each, joined one another to reach the bottom of the hole.
Concrete is then poured through the pipe. By continuing to pour concrete, the trench is filled from the bottom, and the bentonite slurry comes out of the trench mouth *(the slurries are separated from concrete due to lower density)*.

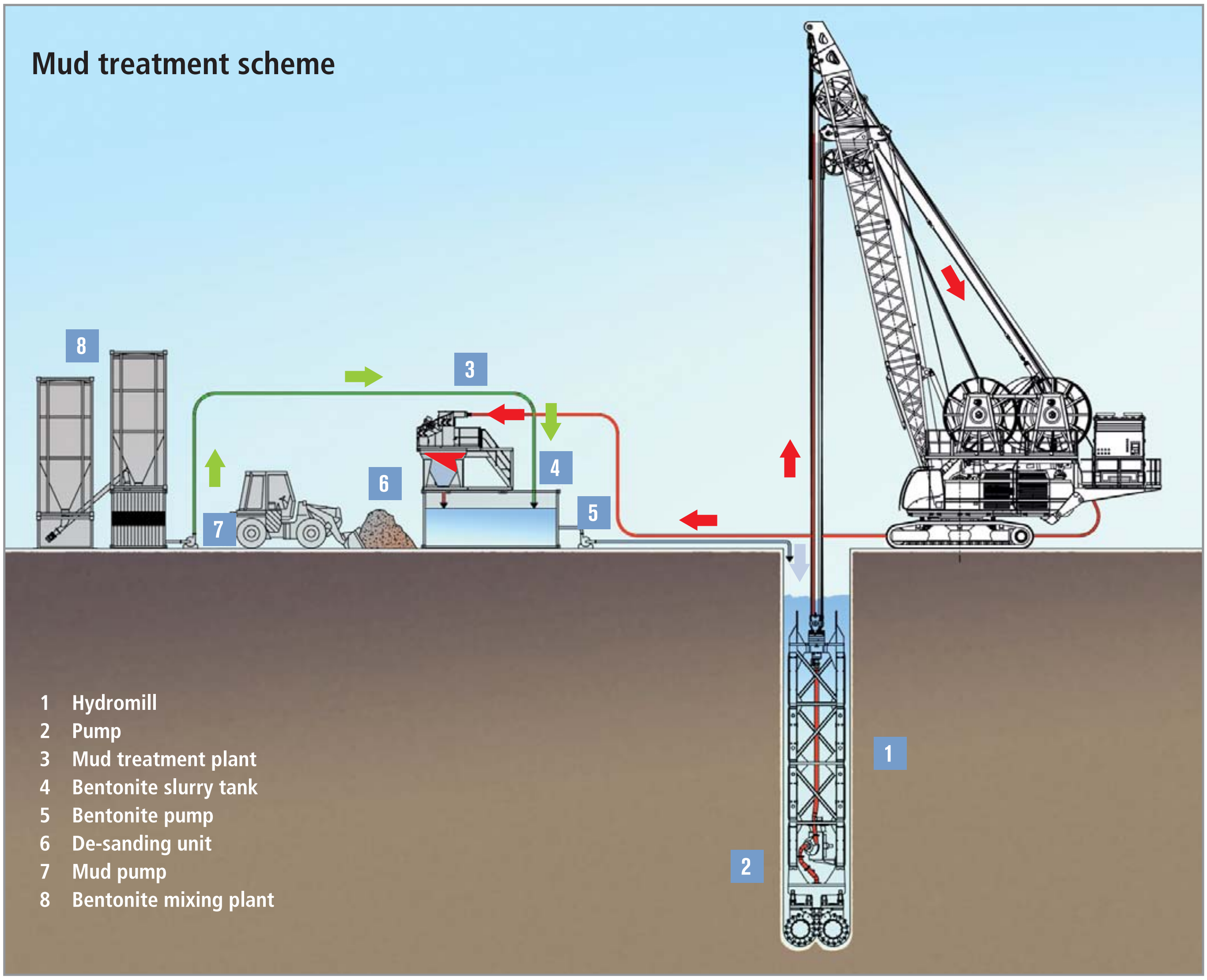
In case of very wide primary panels, it is advisable to use two pipes through which the trench is filled with concrete.

When excavating the secondary panel, it is important to prevent the concrete poured in the primary panels from occupying the upper part of the pre-trench, because this would make it difficult for the hydromill to lower and reach the depth at which the slurry suction pump is activated. To this end, it is possible to use a short sheet stop end driven in place before concreting the primary panels.

Technology and equipment

The hydromill system consists of three main pieces of equipment the milling unit, the carrier supporting it and the mud processing plant to treat the mud extracted from the excavation.
The milling unit is made up of a steel frame onto which two independent counter-rotating milling drums are assembled.
Milling drums with different torques and dimensions can be used to better suit the geometrical requirements.
The milling unit is cable-suspended to the supporting crane's boom and controlled by means of a precision hydraulic system.
The hydromill is progressively lowered into the trench; it excavates and crushes the soil or rock throughout the whole section of the trench.
A submerged pump is positioned right above the milling drums. It triggers a reverse circulation of the stabilizing fluid *(bentonite/polymer slurry or water)*, which acts as a transport medium to evacuate the cuttings from the trench, and sends the mud mixed with cuttings to the mud treatment plant. This is where the cuttings are separated from the stabilizing fluid by means of vibrating screens or cyclones, depending on particle size. **The mud treatment plant shall be usually capable of processing from 300 to 500 m^3/h.**

Mud treating is also aimed at reducing sand and silt content in the slurry (de-sanding) in order to meet the project parameters of density and sand content in the mud of the panel, before concreting.
Cleaned and fresh mud is fed back into the trench to maintain the mud level needed for the stability of the trench.



The hydraulic motors for the submerged elements - *two milling drums and mud pumps* - can be powered either by an external hydraulic power pack mounted on the carrier, or directly by the hydraulic carrier engine. Both hydraulic hoses and reverse circulation drilling mud pipes shall follow the movement of the milling unit.

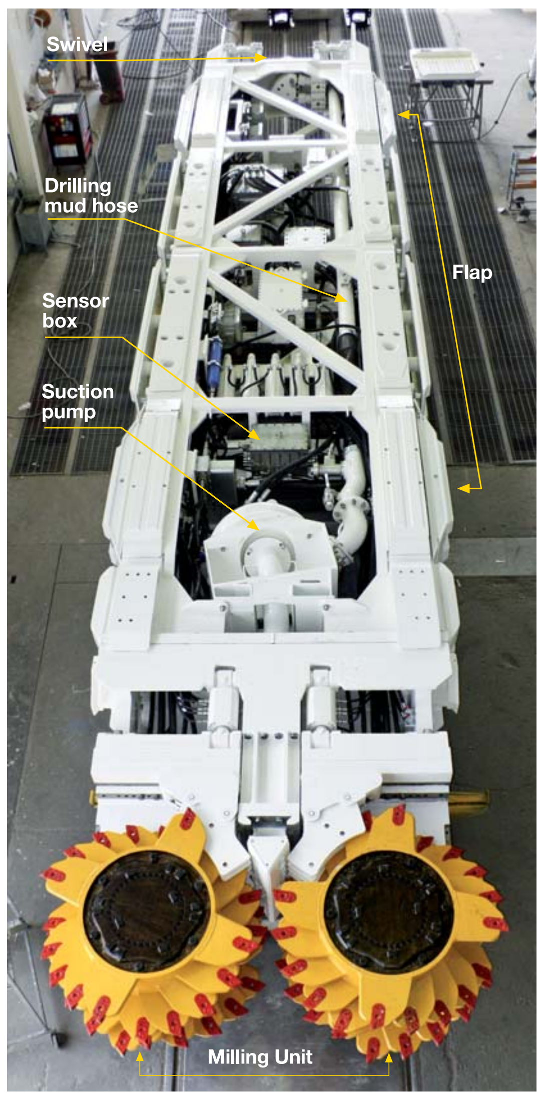
a) SOILMEC 'Tiger' series hydromill
(hose drum design)

b) SOILMEC 'Cougar' series hydromill
(hose wheel design)

Two configurations are usually adopted:

a) with hose drums *(for hydraulic, electric and cuttings suction hoses)* **fixed onto a frame mounted on the carrier;**

b) with hose wheels suspended at the top of the carrier boom.



Technology and equipment

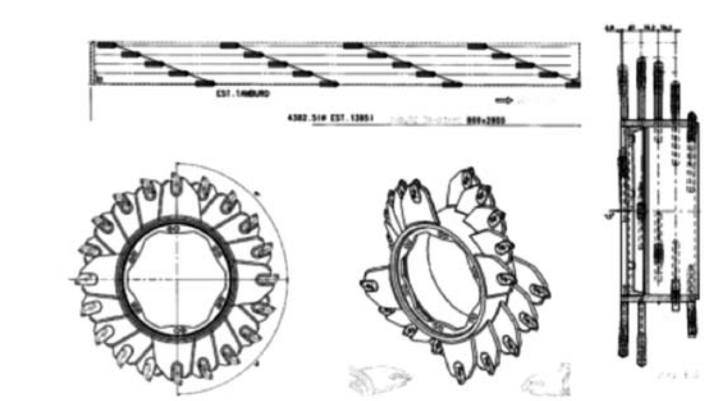
The hydromill always rests at the bottom of the trench and crushes the material across the whole front section. Different types of teeth can be assembled to the milling drums. Tooth configuration can be adapted to soil nature.

Generally speaking, the teeth have either one of the following shapes:

- **flat**, with carbide plate, suitable for mixed soil conditions;
- **conical**, with carbide round insert, suitable for rocky soils.

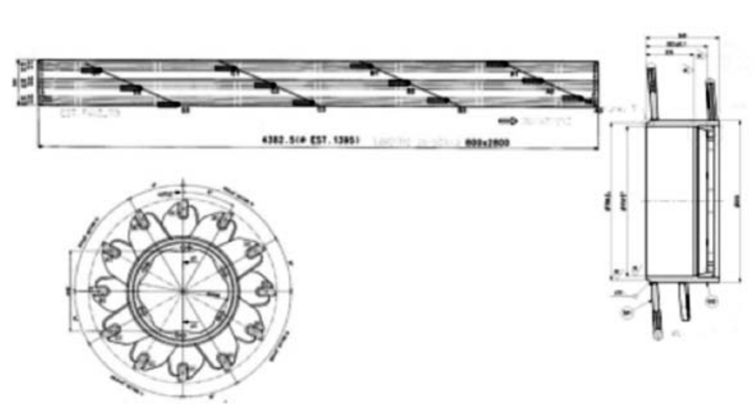
Teeth can be arranged on the milling drums in three different ways:

Type A drum
Suitable for coarse and cohesive soils, alluvial soils with small-sized boulders and medium-soft rocks.



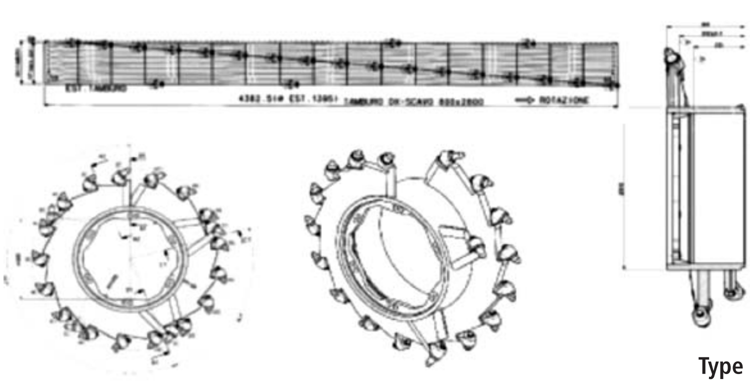
Type A

Type B drum
Suitable for medium-soft rocks and fractured medium-hard rocks.



Type B

Type C drum
Suitable for medium and hard rocks up to 50-80 MPa.



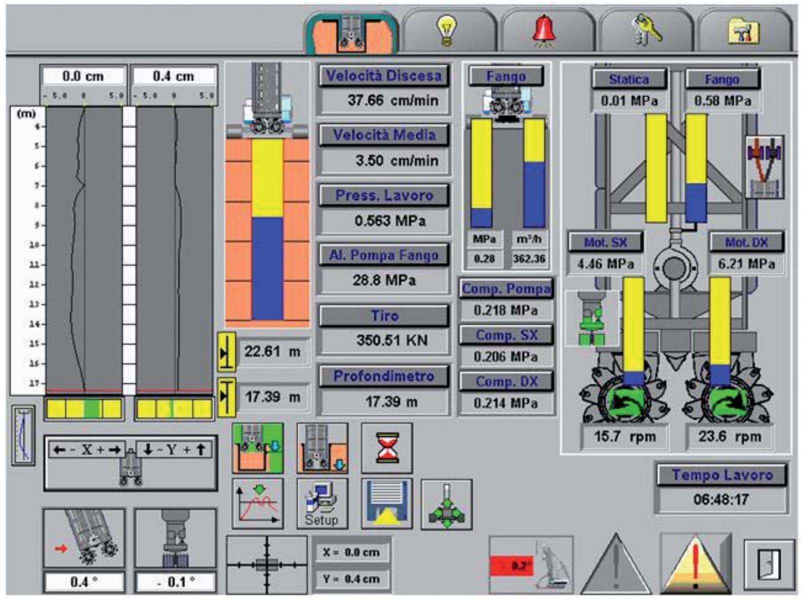
Type C

Controls

In the construction of diaphragm walls by hydromill, the **DMS** plays a crucial role for the management, control and monitoring of the production process. Indeed the operator has to manage and control a number of parameters to ensure deep excavations are properly executed.

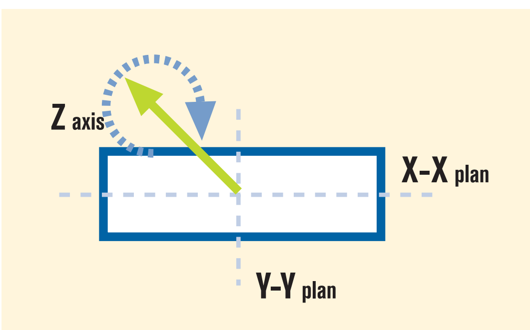
Among them , worth mentioning are:

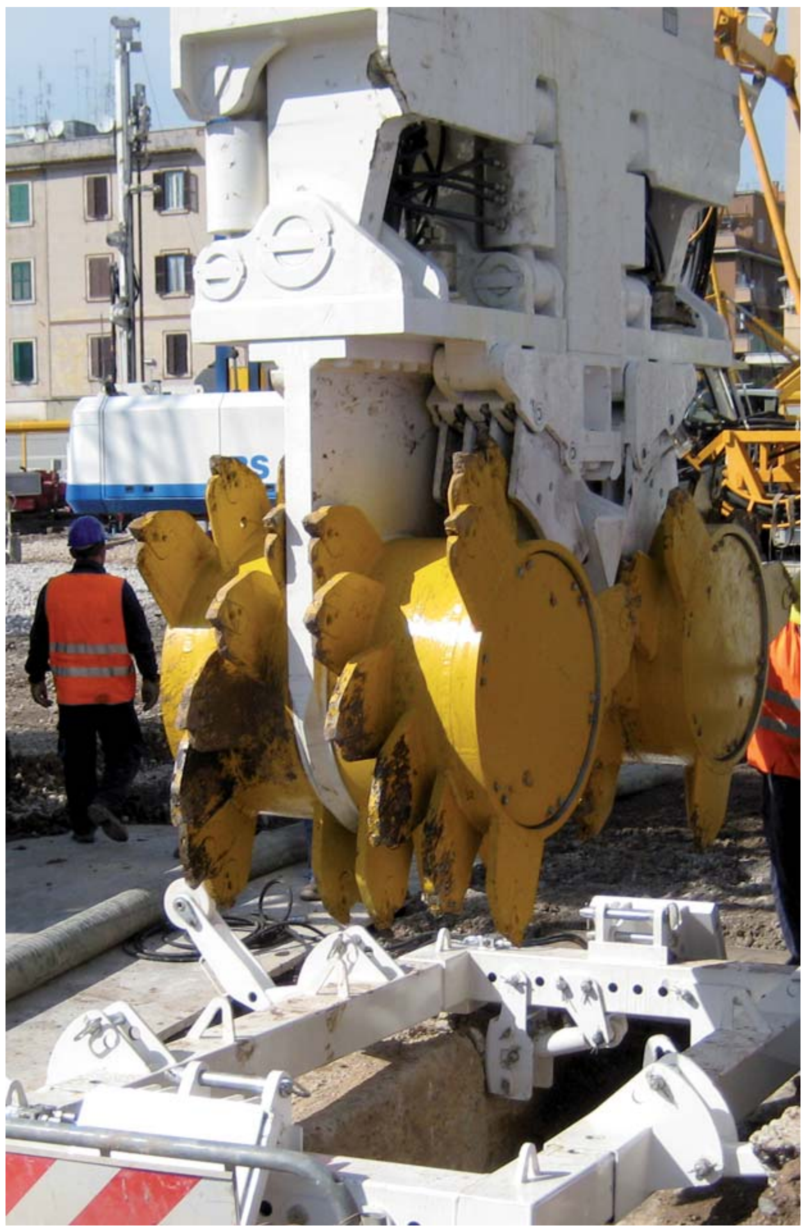
- milling drum rotation speed and applied torque;
- hydraulic back-pressure in the hydraulic motors to compensate the pressure exerted from the outside to the inside of the trench, which varies depending on the depth;
- crowd force/load applied to the milling drums to ensure proper penetration inside the trench;
- flow rate and pressure of the mud pump
- excavation deviation from the vertical.



Verticality control is extremely important to ensure project tolerances are respected, which are usually lower than 0.5%.

The milling unit is capable of correcting inclination in both main directions X-X (longitudinal to the diaphragm wall) and Y-Y (perpendicular to the diaphragm wall), although it is often necessary to control and correct the deviation from the vertical Z-Z axis – twisting of the hydromill module in the ground.



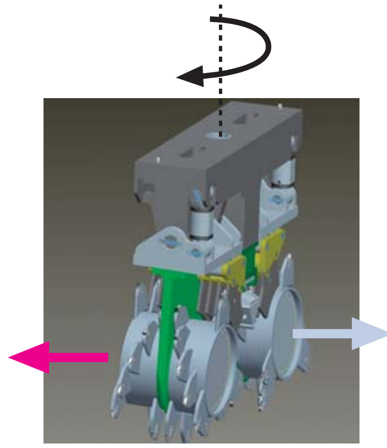


Two methods are available to correct verticality deviation:

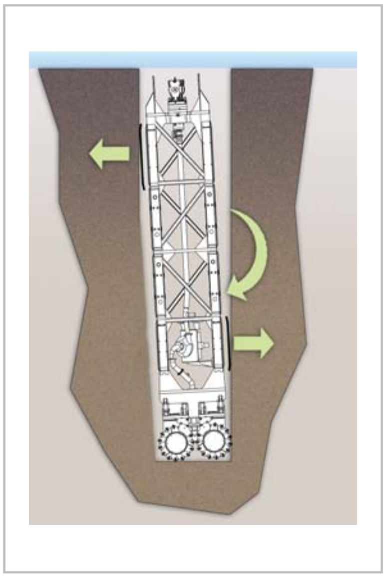
a) **by moving *flaps*** positioned at various positions the hydromill frame, on the four sides, and at the top and bottom of it. Both single and grouped flaps are available: when opened, they project out of the hydromill contour and act against the soil, exerting pressures onto the hydromill module to realign it along the vertical axis.

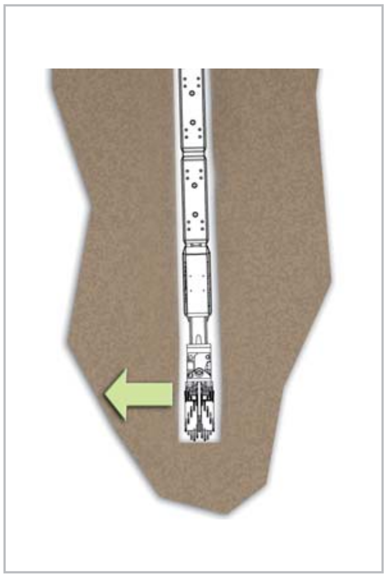
b) **by tilting** the milling drums independently or jointly, in the same direction or in opposite directions.

Controls

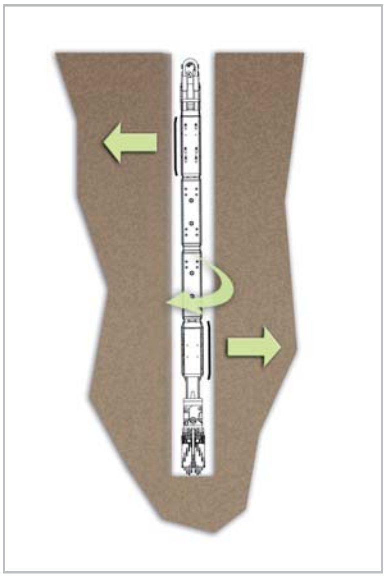


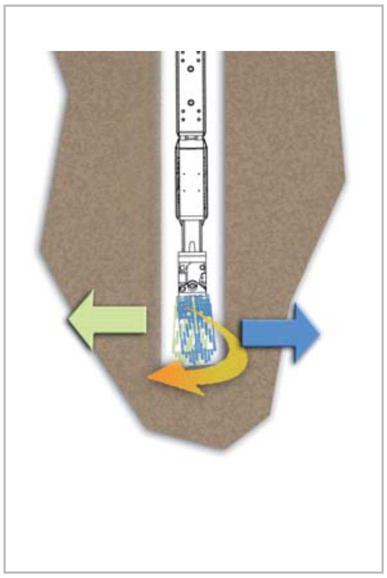
Correction along the X-X axis can be obtained by adjusting the rotation speed of one of the milling drums, or by opening the side flaps of the milling unit.





Correction along the Y-Y axis can be obtained by activating the front flaps of the milling unit or by adjusting the inclination of the two milling drums together and in the same direction.





Correction along the Z-axis can be obtained by activating the front flaps of the milling unit or by adjusting the inclination of the two milling drums in opposite directions.


PIZZERIA
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SEA SIDE
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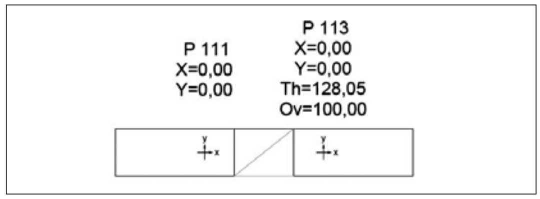
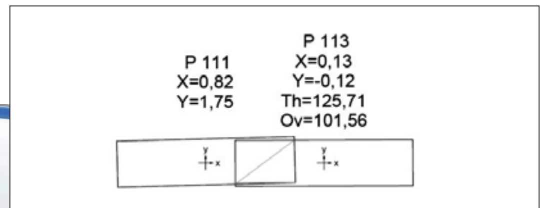
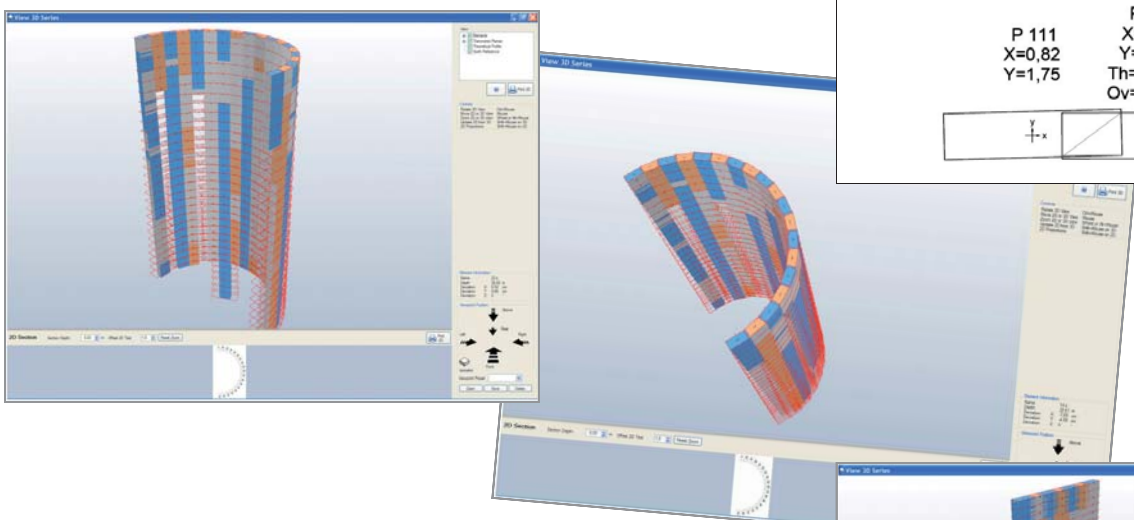
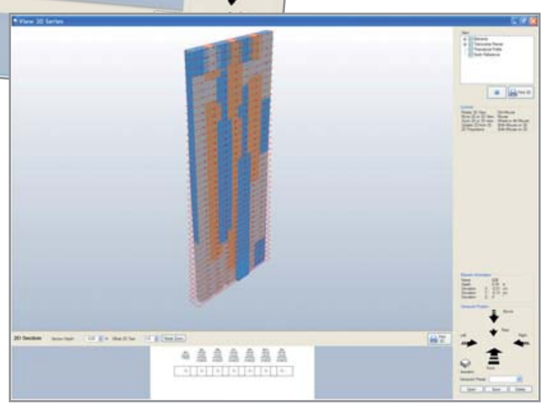
Besides standard data processing and printing out of depth-based excavation trend diagrams, the **DMS** in the PC version also allows to display panel cross-sections at specific depths, with panel overlap area.

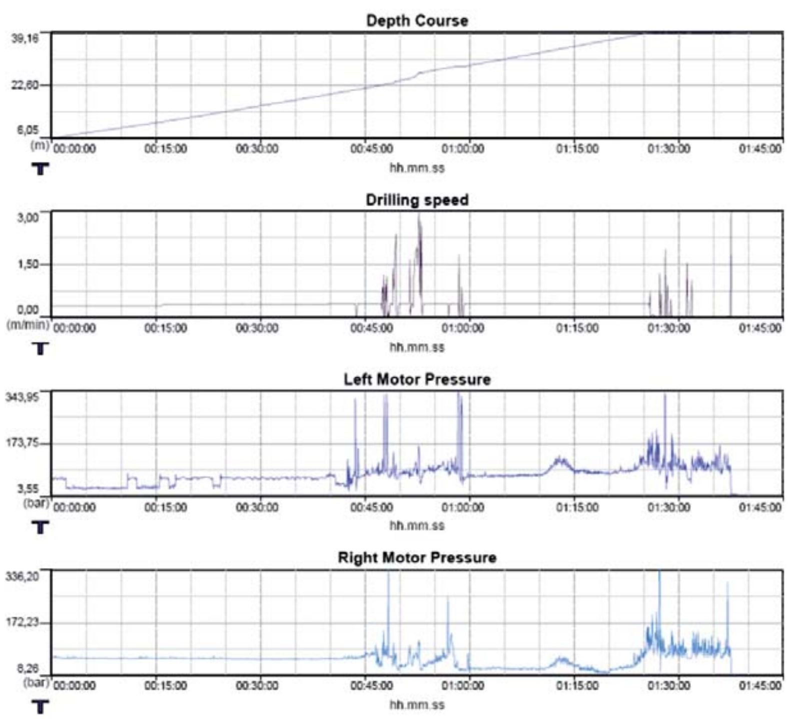
With an additional option to the software, the **DMS can create a 3D rendering** of the project to assess the quality of joints between panels and total deviation of each panel, by combining displacements along X-Y-Z axes.

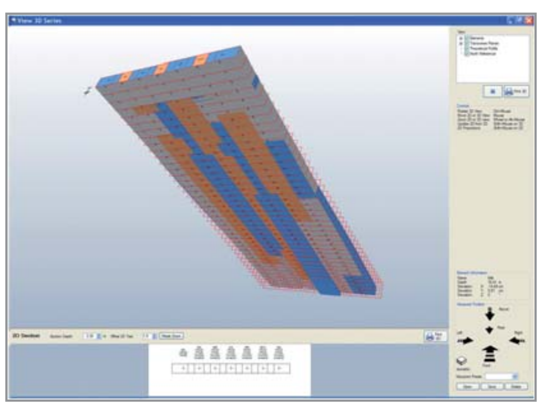












World leader in ground engineering, Trevi has been working for more than 50 years throughout the world, strengthening its ability to provide solutions to any ground engineering issues. Trevi works in the field of special foundation, soil consolidation, dam remedial works, tunnel construction and consolidation, marine works, rehabilitation and cleanup of contaminated sites and construction of underground automatic multi-storey car parks. Trevi is committed to continuous innovation and search for solutions to complex problems of civil engineering 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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