Forth Crossing Bridge, Edinburgh (Scotland). *Off Shore Jet Grouting*

Terratest

Terratest Group

GRUPO
TERRATEST

Presentation

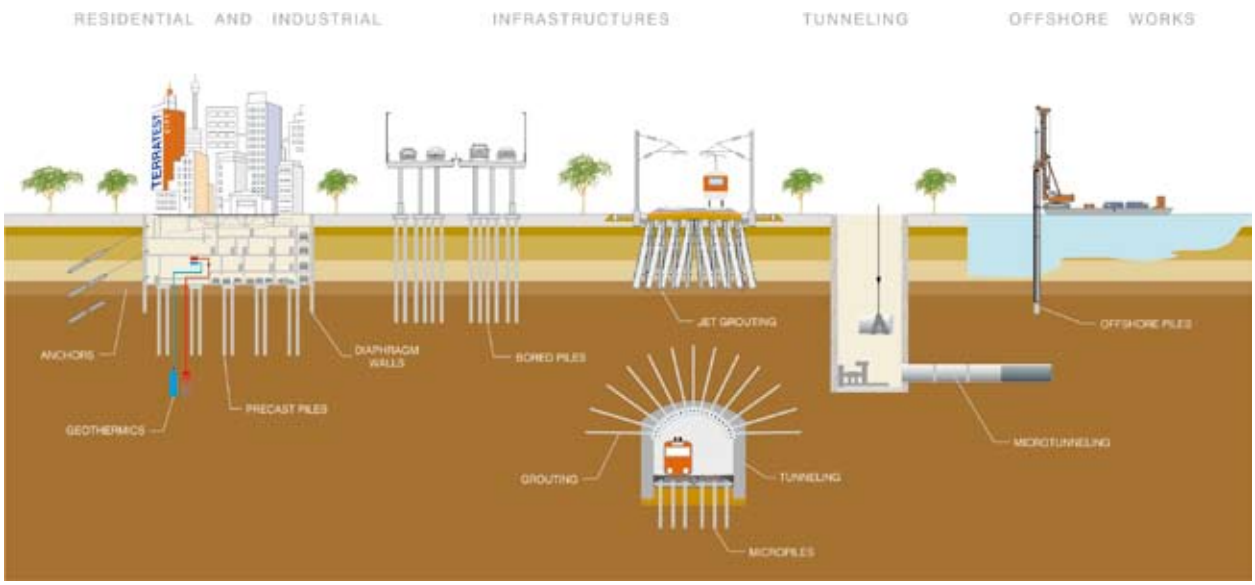
Terratest is an International Construction Group, leader in Special Foundations, Soil Improvement, Microtunneling and the Environmental Sector. Founded in 1959, we are one of the few companies in the world covering the entire range of Geotechnical Works, so we are pleased to offer comprehensive solutions to geotechnical problems of any kind and magnitude.

The aim of our company is to provide suitable solutions to our clients, with seriousness and efficiency, adapting our knowledge and resources to the specifications of each project, and presenting more advantageous alternative solutions.

Tsankov Kamak Dam, Bulgaria
Injection and drainage

Terratest Network

Terratest has a strong international presence and is involved in many major projects carried out in the world. Our international team is ready to face future challenges and demonstrate the adaptability of our company to both developed and emerging markets.



Foundation and Diaphragm walls in Torre Cajasol Project. Sevilla
Diaphragm walls

Activities

Piles

Bored piles

CFA

Precast Piles

Micropiles

Offshore Piles

Excavation Support

Diaphragm walls

Trench Cutter

Soil Nailing

Ground Anchors

Sheetpiles / Metallic Bracing

Ground Improvement

Stone Columns

Jet Grouting

Compensation Grouting

Compaction Grouting

Underpinning

Tunneling

Microtunneling

Consolidation

Horizontal directional drilling

Enveironmental Works

Soil Decontamination

Water reservoirs (Dams)

Urban and Industrial Landfills

Geotechnical and environmental hydrogeology

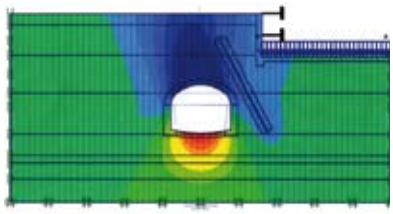
Impoundments Waste

Ground Freezing

Engineering

GRUPO TERRATEST has a technical department consisting of a multidisciplinary team of senior engineers, highly qualified with extensive experience in many fields, including geotechnical, structural calculations (metal and concrete) and of course special foundations.

The technical department of GRUPO TERRATEST uses specialist, last generation software, both in-house developed and acquired, which allows the best of both worlds for each project. Some of these programmes are: Plaxis, Rido, Cype, Ansys, etc. GRUPO TERRATEST's specialists are experts in the use of this software and they have years of experience in the field of geotechnics applied to special foundations.



Activities

PILES

BORED PILES

Concept and characteristics

Extraction piles, bore-cast and concreted «in situ», constitute one of the classic foundation systems for problems arising from the land's support capacity or from the need to carry heavy loads transmitted by the structure to which the foundations are destined.

The pile diameters that can be achieved have no limitation, but generally vary progressively between 400 and 2500 mm. The depths that can be reached exceed 60 m.

Procedure

There are basically three phases in the procedure for a pile bored and concreted «in situ»:
a) The bore
b) Installation of reinforcement
c) Concreting
The characteristics of the land (stratigraphy, water level, etc.) condition the bore type and system: dry rotation, rotation with recoverable casing,rotation with muds or polymersic mixtures and, finally, with and recoverable casing chissel&grab.

Applications

Bored piling is popular to be used in construction as a foundation, especially for bridge work and tall buildings as well. Usually bored pile is used for those tall buildings or massive industrial complexes, which require foundations that can bear the load of thousands of tons, most probably in unstable or difficult soil conditions.

Piles are also used to protect digging in the supporting of soil. Depending on the characteristics of the soil to be retained, they are set apart at a tangent and even secant piles.

East dock restoration in La Coruña Port, Spain
Bored Piles

Nova Arquibancada da Marquês de Sapucaí . Rio de Janeiro/RJ. Brasil
CFA and Precast Piles

CFA

Concept and characteristics

The continuous auger bored piles belong to the category of bored piles with partial soil removal. Drilling is performed by means of a hollow, continuous auger.

This technique allows the production of piles with diameters varying from 300 to 1000 mm, for a maximum depth of 30 meters.

Procedure

A hollow auger is inserted into the ground once the necessary depth has been worked out, and then concrete is pumped down the hollow stem. At the same time, the hollow auger is withdrawn and, in order to reinforce the piling, a reinforced cage is used.

It is possible to monitor the entire installation process of the piles. A flow meter provides accurate data that is then recorded and can be analyzed. Information that is collected includes penetration/uplift per revolution, auger depth and injection of pressure at the head of the auger.

Applications

One of the benefits of CFA piles is that there is no casing involved and so there is minimal disruption associated with using them. They also help to keep vibrations to a minimum and can be used on large projects, making them a good piling solution for a range of situations.

CFA piles are a type of piling that is especially good for use on building sites where there is a need to keep noise to a minimum.

Clinker mil in Toledo, Spain
Precast Piles

PRECAST PILES

Procedure

The piles are driven with modern, free-fall equipment, using a hammer of between 5 and 9 tons raised either by a simple cable system, or the most advanced hydraulic drive methods with high performance and controls. This equipment is completely autonomous (requiring no auxiliary components) and mounted on crawler-cranes for easy movement.

Precast square elements are joint together with special keys (ABB seal) designed by Terratest technical department. The ABB seal is the element allowing the union of different pile sections, to reach the necessary depth. These seals are made with high-quality materials, and calculated to bear greater stresses even that the pile's standard section, as demonstrated in bending, compression and traction trials.

Structure LAV Levante, Section Villena Sax, Alicante, Spain
Precast Piles

Applications

Precast piles Applicattions

Precast piles are especially utilised for their low cost advantages, for sites in remote areas and for foundations with contained vertical loads applied.

Precast prestressed piles Applicattions

Because of the initial prestress force, TERRA's precast prestressed piles are particularly indicated for the absorption of traction and bending strains, and horizontal thrust, giving foundations which are more economical than other designs.

The following may be highlighted, among other applications:

- Structures (bridges and viaducts).
- Tall buildings or those situated in earthquake zones.
- Structures and buildings where the ground floor or basement levels are below the water table.
- Contention of walls, basements, etc.
- Industrial buildings with significant horizontal or bending stresses.

Pre-cast Reinforced Concrete Piles. Technical Specifications

	T-200	T-235	T-270	T-300	T-350	T-400
Theoretical Section cm2	400	552	729	900	1225	1600
Longitudinal Reinforcement (B 500 SD)	4 Ø 12	4 Ø 16	4 Ø 16	4 Ø 20	4 Ø 20	8 Ø 16/20
Transversal Reinforcement (B 500 SD)	19,6 cm.	17,2 cm.	15,2 cm.	13,7 cm.	11,8 cm.	10 cm.
Structural limit (Tn.) (CTE-2006, GC-2002)	61,7 Tn.	84,8 Tn.	112 Tn.	137,9 Tn.	187,7 Tn.	244,8 Tn.

MICROPILES

Concept and characteristics

Micropiles are small diameter cylindrical holes (between 114 and 400mm), into which a tubular metal frame is introduced, normally with a high elasticity limit (also bar reinforcement is used). It is joined to the ground by the means of a pressure injection of cement grout or mortar.

Procedure

1. BORING

The technique used to bore for a micropile depends basically on the type of land involved. While there are several boring procedures, the following are the most used:

- OD.
- ODEX.
- Rotation.
- Hammer rotopercussion at the head.

Although it is not necessary in some cases to protect the bore against internal land collapse, it is usual to use recoverable casing, and sweeps with water and compressed air. If the land is not stable for boring, it may be necessary to use waste tubing, which can substitute for or complement the reinforcing required. The bore is washed with water and/or pressurised air. If the reinforcement is tubular, which is the most-used, it goes into the bore once the washing is finished. Bar reinforcing is introduced once the bore is grouted.

2. GROUTING

Grouting is done using the reverse circulation pumping technique for the cement or mortar.

For tubular reinforcement, pumping is done through the tube, to the bottom of the bore, then up through the annular space formed between it and the land, shifting the bore detritus with it. If the tubing is itself the reinforcement, grouting is done following bore cleaning. If a bar, it is grouted following washing, and the bar is introduced immediately afterward.

Applications

The applications are many, most particularly in all types of work involving reduced space or where large machines are not possible because of their excessive weight:

- Rehabilitation of all types of buildings.
- Underpinning.
- Foundation reinforcement in building extensions.
- Deep foundations on small plots.
- Support for existing foundations for basement excavation.
- Slurry walls in reduced spaces.
- Slope stabilisation on roads.
- Fore-poling for tunnel openings.
- Deep foundations on land not suitable for conventional piling.

Excavation pit in Almeria, Spain
Micropiles

Shopping mall El Corte Inglés. Albacete, Spain
Diaphragm walls

EXCAVATION SUPPORT

DIAPHRAGM WALLS

Concept and characteristics

Continuous reinforced concrete core walls are vertical walls made in spans of up to 7 metres in length and thicknesses between 0.40 and 1.50 metres, and depths of up to 70 m, and offer a solution to excavation difficulties in urban areas or around the water table level.

Procedure

To install diaphragm walls in the ground, mechanically-driven grab buckets are used with weight ratings of between 5 and 23 Tons and grab openings of between 2.60 and 4.20 metres. The grab will start the excavation to the projected depth, normally with the help of bentonite slurries. These liquids, of variable density (and whose principle component is bentonite) allow the excavation to be completed cleanly and do not trigger landslides from the surrounding walls. The bentonite can be introduced into the excavation cavity by pumps from storage tanks.

Once the foundation trench is excavated (the name given to the hole from the depth and maximum aperture of the hydraulic grab, cable or rotary to the hole to be filled with thixotropic cement) the steel support indicated in the framework and cutting plans is introduced, then the concrete is poured through an elephant trunk system, consisting of a bell type tongue and grove system (tremie pipe). With the help of excavation or other auxiliary equipment the framework is introduced and concreted whilst the excavation begins on the next trench. These

steps are repeated successively until the completion of the diaphragm walls around the perimeter of the site.

Applications

They are used in a large number of projects (bearing structures, provisional or definitive retaining walls, etc.) and represent a solution to different problems such as the excavation of buried structures such as underground car parks and basements, subways, etc., to the creation of subsoil waterproofing in loose material dams.

TRENCH CUTTER

Terratest is one of the world leaders in the execution of Diaphragm walls with Trench Cutter. A Trench Cutter is a reverse circulation excavation machine, consisting of a heavy steel frame and two cutting wheels attached to its bottom end. The wheels rotate in opposite directions around horizontal axes, breaking the soil beneath the cutter and pumping it out of the trench to a complex desanding plant.

The Trench Cutter is utilized:

- For the excavation of hard rock formation
- For large thickness and depths
- And when high accuracy is required

Sant Ponz pit. Gerona, Spain
Trench Cutter

New High-speed railway station.
Gerona, Spain
Diaphragm walls, Bored Piles, Trench Cutter

Car park in Portugalete Square. Valladolid, Spain
Ground Anchors
Car park in Torrelavega Avenue. Asturias, Spain
Metallic Bracing

SUPPORTS

Diaphragm walls can be free standing, or together with others, which can work as a cantilever. This solution needs a recess depth of the large wall and high quantities of steel. This makes it necessary to study solutions that provide support to the wall during the excavation and reduce forces and deformations to the wall.

The type of bracing most commonly used is that completed through ground anchors, which facilitate the construction of slabs. However, for economic reasons or influenced by the construction process, other varieties of bracing exist, among them:

- Anchors
- Metallic bracing.
- Anchors + metallic bracing.

GROUND ANCHORS

Ground anchors (both temporary and permanent) are a technically and economically competitive solution, because they facilitate the process of bracing and reduce the execution time of the works, providing a high level of security thanks to the technical development experienced in recent decades. Ground anchors are principally designed to absorb tensile forces. To perform this task, the anchors are divided into four parts:

- The bulb: transmits traction to the ground via its shaft that induce tension.
- The free extension zone: situated between the anchorage zone and the head of the anchor, and where no forces are transmitted to the surrounding ground allowing the bulb to be situated in stable ground levels, outside of areas of slippage.
- The anchor head: that connects the structure (mainly Diaphragm walls) and must fully absorb the tension of the reinforcement.
- Anchor reinforcement: transmits the tension from the head to the bulb, passing through the free extension zone.

Some of the applications of ground anchors are as follows:

- Bracing of retaining structures.
- Diaphragm walls.
- Curtain walls of piles.
- Walls constructed by foundation trench in descending phases.
- Micropile walls.
- Sheath piling.
- Stabilisation of slopes

METALLIC BRACING

The scope of use of the TERRATEST metal bracing system includes any type of work (building and public works) in which a Diaphragm walls, of any type (continuous, pile or micropile) is to be constructed, and in which metal bracing is feasible geometrically.

TERRATEST is able to offer its customers a metal bracing system designed to measure, and meet their needs from a technical and economic standpoint, and in addition, provide technical advisory services at the highest level.

SHEETPILES

Sheet piling is an earth retention and excavation support technique that retains soil, using steel sheet sections with interlocking edges. Sheet piles are installed in sequence to design depth along the planned excavation perimeter or seawall alignment. The interlocked sheet piles form a wall for permanent or temporary lateral earth support with reduced groundwater inflow. Anchors can be included to provide additional lateral support if required.

Terratest Group supplies and installs vibratory-driven sheet piles for both permanent structures and temporary retaining walls or construction pits. The possible applications vary greatly, depending on whether the work will take place on land, on the water or along a railroad.

Sheet pile walls have been used to support excavations for below grade parking structures, basements, pump houses, and foundations, construct cofferdams, and to construct seawalls and bulkheads. Permanent steel sheet piles are designed to provide a long service life.

Somport Tunnel. Huesca, Spain
Ground Anchors

SOIL NAILING

Soil nailing is a technique used to bring soil stability in areas where landslides might be a problem. Soil nail can prevent landslides by inserting steel reinforcement bars into the soil and anchoring them to the soil strata. It is called Soil Nail, because it's like having a nail being hammered into the soil, where the nails, are the steel bars.

Procedure

Its construction process is faster than other similar methods. The construction procedure starts, drilling into the soil, where the nail, steel bar, is going to be placed. After the drilling has been completed, exact depth must be provided by the geotechnical engineer, the nail must be inserted into the drilled hole. Then, it must be grouted into the soil to create a structure similar to a gravity wall. After placing the nail, a shot-Crete layer is usually placed as a facing material, to protect the exposed nail, and then other architectural options are placed over the shot-Crete, creating an aesthetic finish to the project.

Soil Nailing is not recommended to use on clayey soils, and or clean sands where the cohesion of the soil is minimum.

Landslide in Bonares. Huelva, Spain
Soil Nailing

GROUND IMPROVEMENT

STONE COLUMNS

Concept and characteristics

As a general rule, stone columns are executed with a vibrator with lower discharge and a discharge chamber and an extension feed tube on the top. Thanks to the feed tube and the compressed air, the gravel is pushed to the end. For this special equipment, Terratest has created a guide frame that enables driving and lifts the vibrator, the gravel then falling into the outlet hole. The vibrator then drops back down into the gravel, compacts it and expands sideways against the soil. The columns produced in this way bring together the essential loads to be withstood.

Geotechnical aspects

Unlike vibro-compactation, an improvement in compactness between columns is not initially considered, although it does arise in some cases. The improvement lies in the extremely elastic flexible module inclusions, without cohesion, which have an improved supporting capacity to decrease and control settlements.

Procedure

1. Preparation

The machine is positioned over the drive point and stabilised on the skids. A loader supplies the gravel.

2. Filling

The contents of the hopper are poured into the tube. On closing it, the compressed air allows for a continuous flow of gravel to the outlet hole.

3. Driving

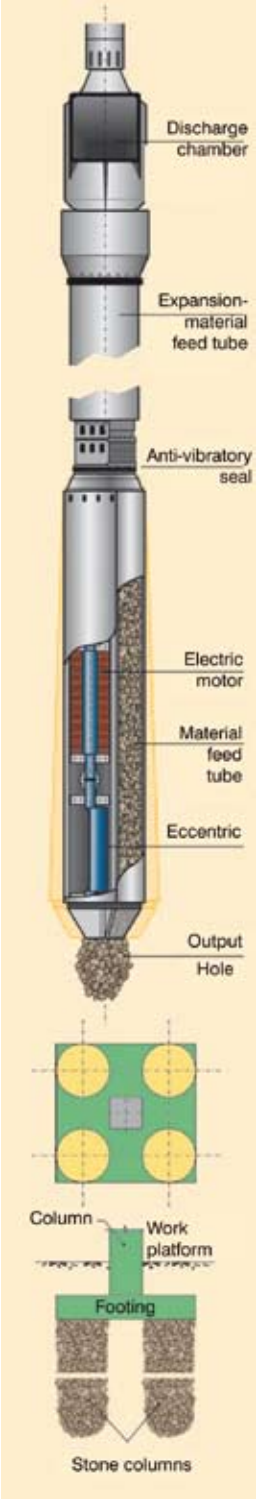
The vibrator descends, moving the soil sideways, to the planned depth thanks to the compressed air and the static drive of the unit.

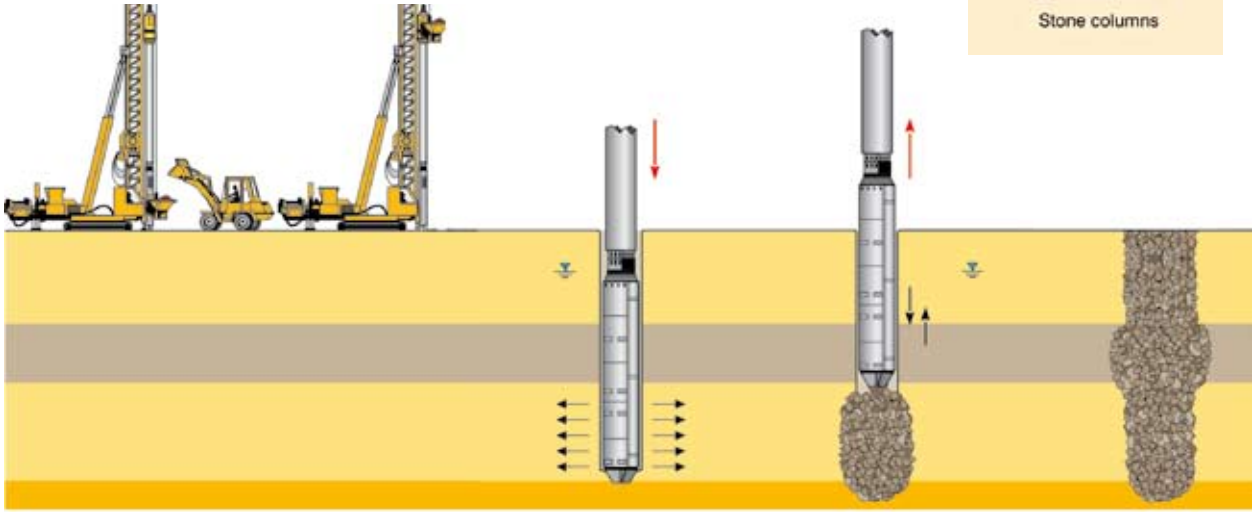
4. Compactation

When the final depth is reached, the vibrator is lifted slightly and the gravel takes up the freed space. The vibrator is then lowered again to expand the gravel sideways against the soil and compact it.

5. Finish

The column is produced in this manner on successive drives up to the planned level. The foundation footings are then executed directly in the traditional manner.





Juan Gonzalo Pier Huelva Harbour
Jet Grouting

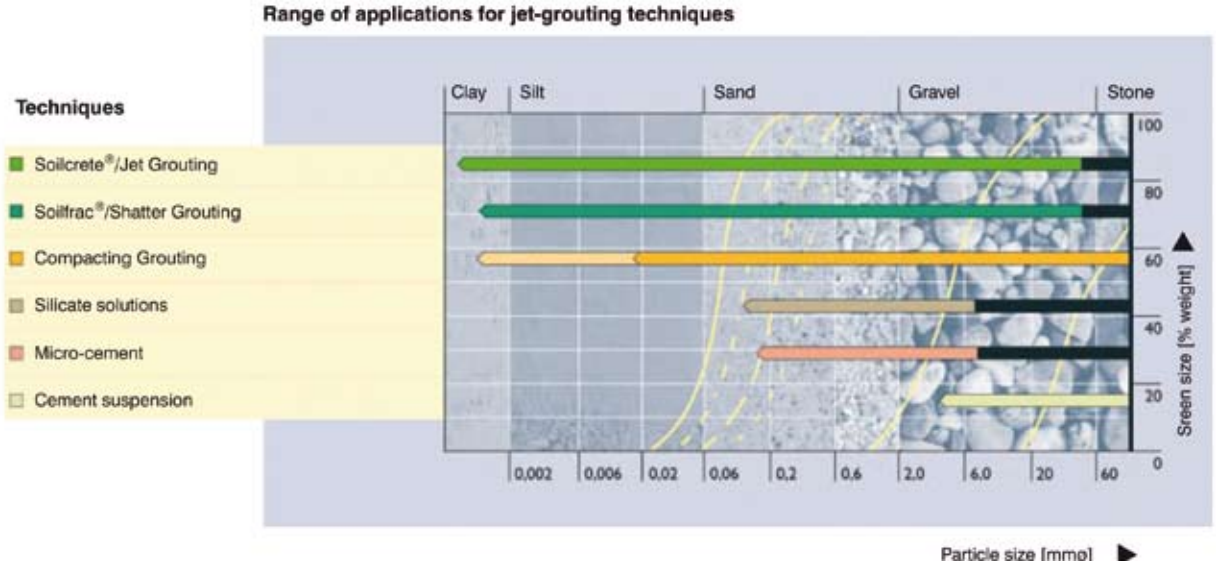
JET GROUTING

The Jet Grouting process

The Jet Grouting process or Soilcrete is known as a soil-cement stabilisation.
The soil around the bore is eroded with the aid of a high-pressure jet of water or cement suspension with a nozzle output speed 100 m/sec (possibly airborne).
The eroded soil is rearranged and mixed in the cement suspension. The soil-cement mix is partly ejected into the annular space between the Jet Grouting rod and the bore. Different geometric configurations of Soilcrete elements are possible. The jet erosion distance varies according to the soil type and jet fluids used, and can reach diameters of up to 5 metres.

The Advantages of Jet Grouting

- Applicable to almost all soil types
- Individualised in situ treatment
- Designable strength and permeability
- Specific layer treatment
- Inert components only
- Vibration-free
- Applicable in limited working spaces
- Possibility of different Soilcrete elements
- Maintenance-free
- The safest and most direct underpinning method
- Able to operate around underground installations in servce
- Faster than alternative methods



COMPENSATION GROUTING

Concept and characteristics

By using this process, fractures are created in the soil that are subsequently filled with cement grouting. Any formation in the soil can be improved by grouting and may controlled.

Procedure

1. Installation of the hose and inserting of the sheath

The hose is fitted into the bore hole drilled, filling the annular space between the bore hole wall and the hose pipe with a bentonite-cement mixture.

2. Soil breakage

In order to inject the suspension, a double shutter is inserted that separates each of the hose pipes during grouting.

3. Multiple grouting

The hose pipes can be inserted one or several times, depending on the technical requirements. The volume of grouting, the maximum grouting pressure and, in the case of repetitive grouting, the grouting speed are kept in line with instructions. The hoses pipes can be reused.

Applications

Restoring foundations

The footing and subsoils form part of the foundations of a structure. Over time, both can fail for different reasons. This is often the case in historic buildings.

In the case of excessive settlements, compensation grouting is a suitable process for restoring the link between the base of the structure and the supporting soil.

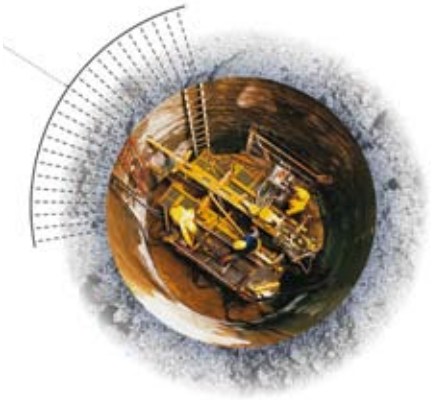
Elevating Structures

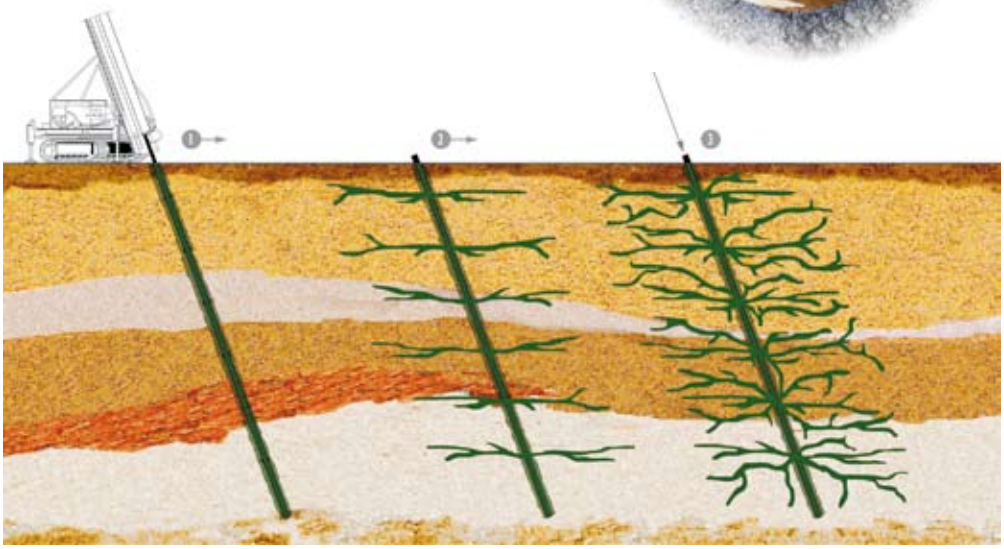
The settlement of structures can be solved using the compensation grouting. Depending on the condition of the building and the soil, the speed of elevation can be adapted to each case.

Partial and precise elevation within the range of millimetres is combined and added to total elevation within a range of decimetres, without damaging the structure. Structures are normally lifted without impeding their use.

Protecting Structures

To protect structures from foreseeable settlement during the construction of a tunnel, ranges of horizontal hoses are to be installed from temporary shafts between the tunnel vault and the foundations of the building. The building to be protected will be fitted with an electronic measuring system to record vertical movements.





Installation point

COMPACTION GROUTING

The method of Static Grouting is based on the injecting of a low mobility mortar into the soil so that the injected mixture does not flow through the soil and remains concentrated around the injection point. This mortar is injected at a pressure of up to 40 bar and with a settlement on the Abrams cone of less than 8 cm, allowing for correct densification. The injected material fills the gaps and compacts or stabilises the soil surrounding the area treated. The mortar cement then sets to give it resistance and hardness. The soil must be displaced during injection without breaking its structure.

1. Installation of the grouting piping

The boring is drilled using rotary or rotary-percussion equipment depending on the characteristics of the soil.

2.Compactation Grouting

The mortar is prepared in the mixer and injected by pressure into the soil using a specific pump for this type of work. Meanwhile, the grouting piping is gradually inserted or withdrawn, creating a column made up of almost round bulbs that join together.

3.Compactation by phases

To ensure uniform soil compactation, grouting is worked onto a primary and then a secondary mesh. In the case of localised treatment, the grouting is worked at the points and with the gradients defined by the calculation.

Applications of Compactation Grouting. Types

Soil improvement

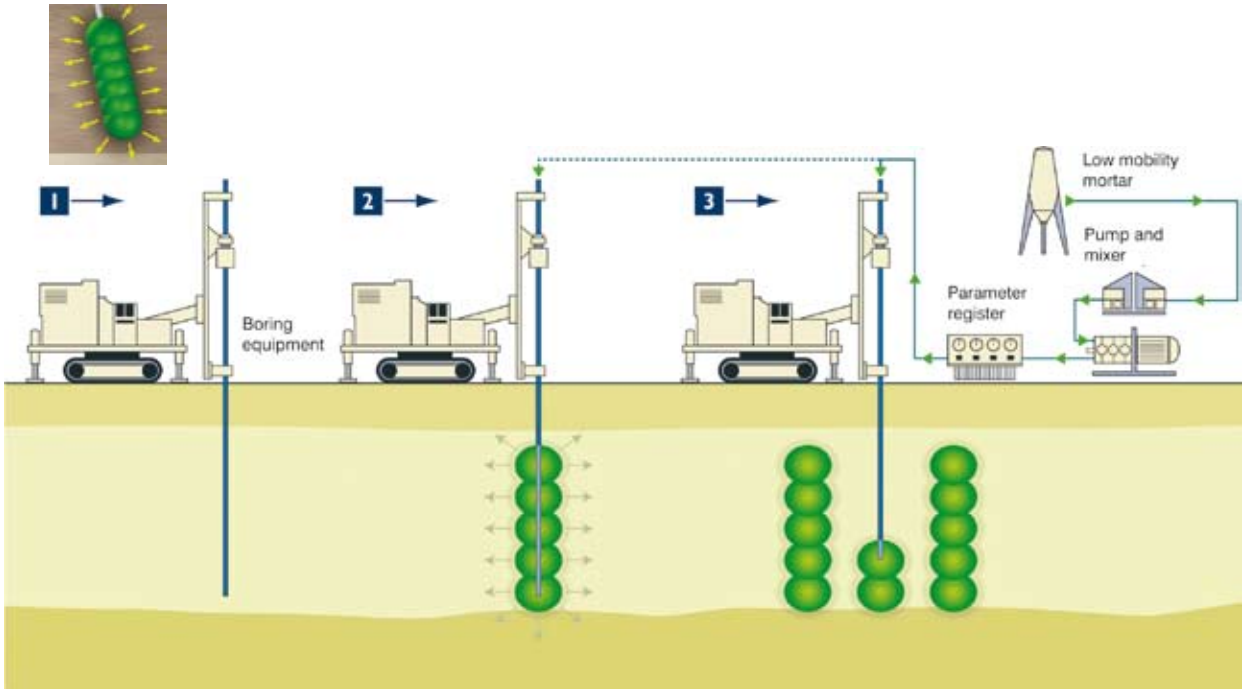
Improvement of soil with low supporting capacity, increasing its relative density. Compacting of non-cohesive soils, especially those with low or medium density with alternating hard or cemented layers. It can be used as an alternative or in addition to pile foundations or soil improvements using gravel columns.

Foundation stabilising and underpinning

Increasing or restoring the supporting capacity of the soil underneath existing foundations, e.g. in the event of an incre se in excess load or to repair damage produced by settlements. This technical is an alternative to the Jet Grouting procedure and/or can be used as a preliminary treatment to apply Jet Grouting and Fracturation Grouting. Recovery of or increse in the supporting capacity along the shaft or the point of existing deep foundations.

Cavity filling

In very porous, eroded soils or those with cavities, e.g. in landfill areas that have not been sufficiently compacted, areas affected by karstification, soil damaged by the breakage ofwater pipes, etc.



Gavilanes landfill. Madrid, Spain
Sealing of landfill

ENVIRONMENTAL WORKS

TERRATEST GROUP can respond adequately to new environmental challenges that are plated, and has specialized media, knowledge and technology to carry out activities in sectors as diverse as the oil industry, mining, waste management, civil infrastructure, tunnels, ports, power generation and distribution, and water supply, among others.

Geotechnical and environmental hydrogeology

TERRATEST GROUP has a team of experts, combining classic and new geotechnical disciplines of applied hydrogeology and environmental management, to offer a wide range of solutions in civil engineering, oil industry, mining, groundwater resources, construction, etc.

Contaminated soils and aquifers

TERRATEST GROUP has the most effective technologies for the remediation, removal and/or confinement of contaminated soils and groundwater, which are combined according to a strategy aimed at reducing costs and environmental risks. We also provide professional engineering services and technical assistant, to carry out characterization studies and risk analysis.

San Juan de Mambliga Dams. Burgos, Spain
Construction and waterproofing of dams for water regulation and storage

Urban and industrial landfills

TERRATEST GROUP offers the best available techniques for performing the work of waterproofing of landfills for municipal and industrial waste. Also we provide research services as location, environmental impact, design and drafting of projects, and control and environmental monitoring.

Sealing and degassing of landfills

The closing and sealing of landfills is aimed at reducing the environmental impact of final disposal of waste on the environment, ensuing isolation conditions in time to prevent contamination of soil and ground water, and the emission of gases and odors to the atmosphere.
In the case of municipal waste landfills, are particular relevant, the actions of degassing and energetic use of biogas generated.

Water reservoirs (Dams)

TERRATEST GROUP has an extensive curriculum of construction dams for water regulation and storage. It is waterproofed with geomembranes infrastructure to ensure that no seepage into the ground, that preserve the water quality to its further use: drinking water, irrigation, industrial, aquifer recharge, etc.

Impoundments Waste

A lot of impoundments for the storage of mine tailing, industrial and leachates has been constructed by TERRATEST GROUP, through the combination of artificial mineral barriers and geomembranes, complying with safety standards and containment to avoid environmental contamination.

Turbot fish farm. La Coruña, Spain
Tunneling
Assembling an EPB machine in the launching shaft
Tunneling

TUNNELING

MICROTUNNELING

INTRODUCTION

In the field of microtunneling Terratest is one of the European leaders, throughout our owned company Eurohinca, providing its own Tunnel Boring Machines and a wide experience in all kind of soil conditions and applications.
T.B.M. is the abbrevation of Tunnel Boring Machine and his definition is equipment capable of digging tunnels to complete section. To restrict a bit this definition we can be divided TBM in several classifications:
- Full face support TBM: TBM able to control the pressure in the front during the excavation. This type of machines can work under cities and cross road, railways, etc.
- Open shields: For stabilize grounds and without any civil construction in the surface.

Depending on the tunnel support
- Segment lining: Can be use in all type of ground and with all type of TBM.
- Metal roof truss: Used only in rock ground and with gripper TBM.
- Pipe jacking: For tunnels with diameter smaller than 3 m.

Depending on the extraction method
- EPB Shield: Extraction with endless screw conveyor.
- Hidroshield: Extraction with pumps.
- Rock TBM, double shield and open shields: Extraction with conveyor belt.

ADVANTAGES OF TRENCHLES TECHNOLOGY

Tunnels<>Trench
- Less effect on existeng services.
- Lower environmental impact.
- Minimizes spoil and waste generated.
- Compact instalation.

TMB<>Mining
- Increased security for workers. (Works inside a shield)
- Less risk of surface settlements. (Excavation Front is supported)
- Higher outputs. Minor delays.
- Reduced impact on ground water level.

TYPICAL APPLICATIONS

- Server and water supply networks. Collectors.
- Crossings under existing services. (road, streets, railways, rivers, airport runways, golf courses, etc.)
- Sea outfalls. Water release or intake.
- Tunnels with tunnel boring machines.
- Underground corridors.
- Gas and oil pipelines. Drainage and evacuation systems.
- Pipe arching for road or railway crossings.
- Steel pressure pipes.
- Water intake and release for fish farm or desalination plants.
- Water waste pipe and intakes in reservoir dam.

EPB control panel
Assembling an EPB machine in the launching shaft
Hydro shield machine in port after an outfall driva
Breakthrough of Hydro shield in reception shaft

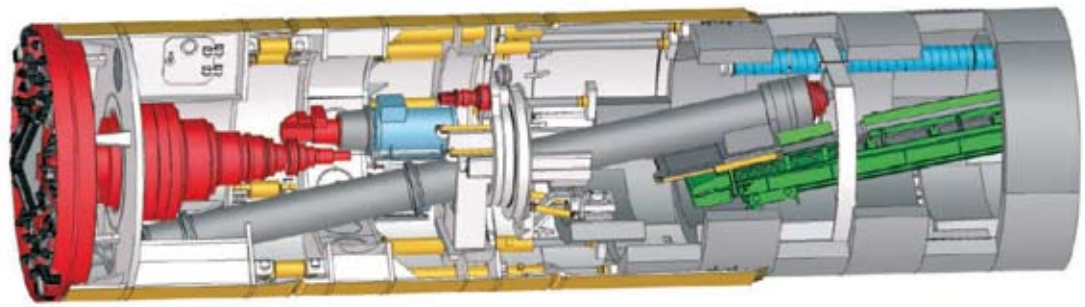
CLOSED FACE TUNNEL BORING MACHINES

EPB SHIELDS

The EPB Shields (Earth Pressure Balance) are TBM machines that support the tunnel face with the pressure applied by the excavated soil located inside the excavation chamber; the controlled extraction of the soil from the excavation chamber by means of a variable speed auger allows the adjustment of the pressure applied to the tunnel face.

The excavated material is transported to the launching shaft by conveyor belts or muck wagons.

The EPB Shields were initially designed to bore soft, cohesive ground, (mainly clay), but with the use of foam and polymers it is possible to bore other type of soils as sand or even rock.

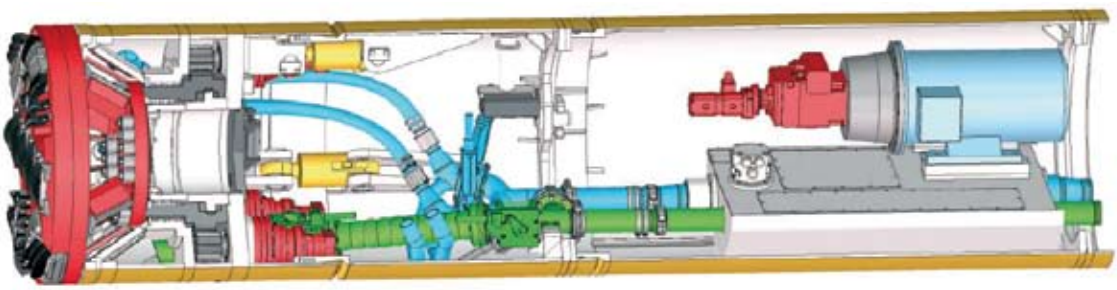


HIDROSHIELDS

The TBM mix shield, or hydro shield, supports the tunnel face by the pressure of the bentonite suspensions injected in the excavating chamber and mixed with the excavated material.

This mixture is crushed in the excavation chamber and is evacuated by hydraulic pumps to the launch shaft where a separation plant separates the excavated material from the bentonite suspension.

The Hidro shield TBM can be used in almost all type of ground, and performs well in sand, rock, under ground water level (Sea outfalls) and it is specially indicated for small diameters.



Roadheader in open shield
Front face in an excavator open shield
Range of ground per TMB
Rock tunnel face

OPEN FACE TUNNEL BORING MACHINES

OPEN SHIELDS - ROADHEADERS OR EXCAVATION

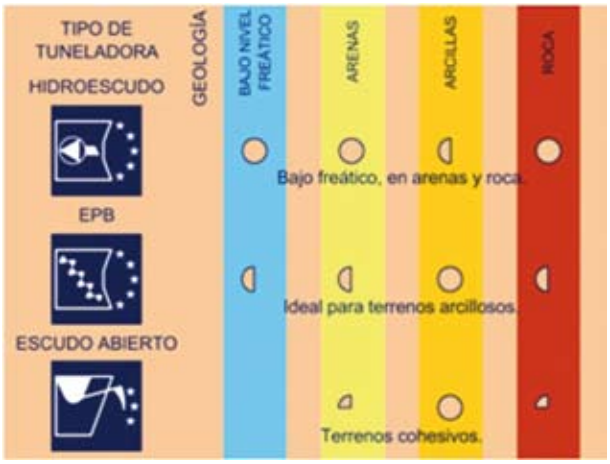
Open face shields allow a visual contact to tunnel face. The front is excavated by powerful roadheaders or excavators. The extraction of the excavated material is made by muck wagons pushed by locomotives or winches.

Ii is economic and optimal solution for non urban with cohesive soils and above ground water level.

TBM CHOISE

A detailed and comprehensive geotechnical study (including ground investigation, ground water level, type of soil, resistance to simple compression, rock abrasivity, etc...) is the basis for the selection of the appropriate TBM equipment and excavation method.

With complete information it is possible to define the most suitable TBM, cutter head configuration and tools, characteristics of the lining, the alignment of the tunnel, and also, if necessary, preventive measures to be taken, monitoring systems, etc...



Segments in the Back up of the T.B.M.
Bentoniteinjection points in pipe jacking tunnel

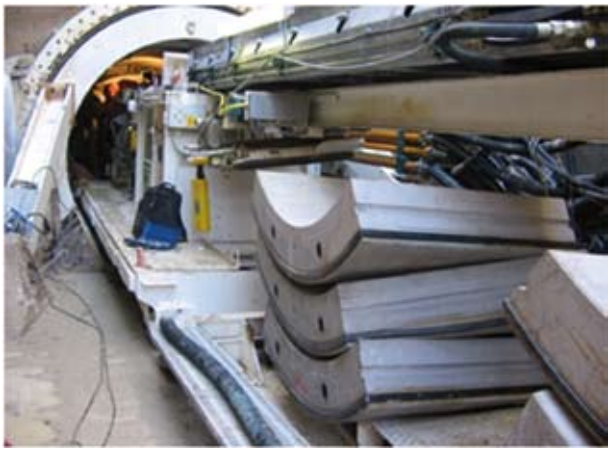
Last lining ring in the reception shaft
Jacking frane in launching Shaft
Downloading a jacking pipe

TUNNELING LINING

SEGMENTAL LINING

Precast concrete elements that are installed inside the tail skin shield of the TBM, building a complete ring that constitutes the final tunnel lining.

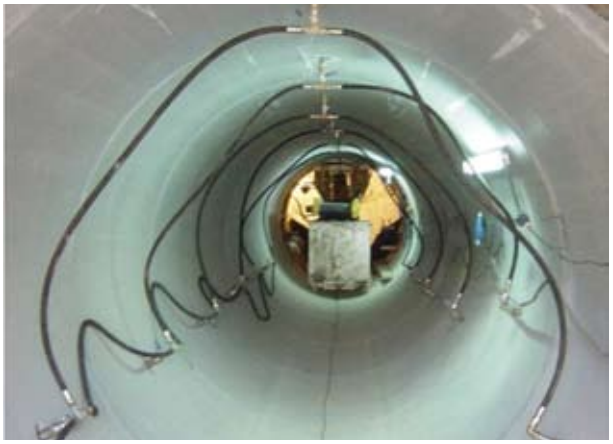
The thrust of the machine is made on the last ring installed: this allows to excavate great lengths and curved tunnels alignment.



PIPE JACKING

Prefabricated pipes (concrete, steel, etc...) that form the lining of the tunnel and are installed and from the launch shaft pushing forward the TBM to the ending shaft.

To reduce the friction between the pipe and the ground during the jacking phase bentonite is injected in the overcut. Intermediate jacking staions are necessary for long dstances.



Tunnel Roveredo, Switzerland
Pipe Umbrella

PIPE UMBRELLA

Support of the gallery by means of forepoling

The method consists of inserting steel tubes inside sub-horizontal holes made ahead of tunnel's face. Structures in the form of pre-shaped arc are obtained in this way as support for the excavation. This system finds its ideal application in heterogeneous loose soils containing boulders and large blocks of rock (debris of avalanche). The installation of these tubes is done by means of special rigs who are very stable and are equipped with long mast. The machine is placed in the center of the arch and only the mast is moved in any position of perforation, without moving the machine itself. The drilling can be done directly with the steel pipe or dragging the same within an outer protective pipe or using a down-the-hole hammer placed inside of the tube itself. Lengths are possible drilling of up to 30 meters, but the optimum value lies between 14 and 18 meters, in this case one piece tubes without junctions can be utilized. The distance between the tubes depends on static factors and the geology and is generally between 30 and 60 cm. The tube diameter is usually between 100 and 180 mm. The tubes are usually fitted with valves and are cemented by the introduction of mechanical single or double packer. Possible deviations of drilling are strongly dependent on soil type.

THE HORIZONTAL DIRECTIONAL DRILLING (HDD)

1 THE METHOD

The horizontal directional drilling (HDD) is the most appropriate and modern technique for pipelines.

This is a technique in which open excavation is replaced by a precision guided drilling, technology carried out with the aid of a pressurized liquid jet.

It can be described as an advanced system for laying underground lines and can be used in crossings of rivers and canals, embankments, roads, highways and railways.

One of its main advantages is to minimize the destruction/ excavation of roads and sidewalks, and reduce he inconveniences of excavation work: noise, dirt, obstruction of trafic, etc..

Our equipment allows us to install HDPE and Steel pipe up to 1400 mm indiameter for lenghts up to 2000 meters both in soils and in rock ground.

2 OPERATION

Step 1: Pilot Drill

A guided drill bit mounted with a hydro-mechanical system is used for the initial bore, making the pilot hole with the default path and depth.

Directional control of the head is three-dimensional, which allows obtaining a high precision in the outlet predefined.

Step 2: Boring

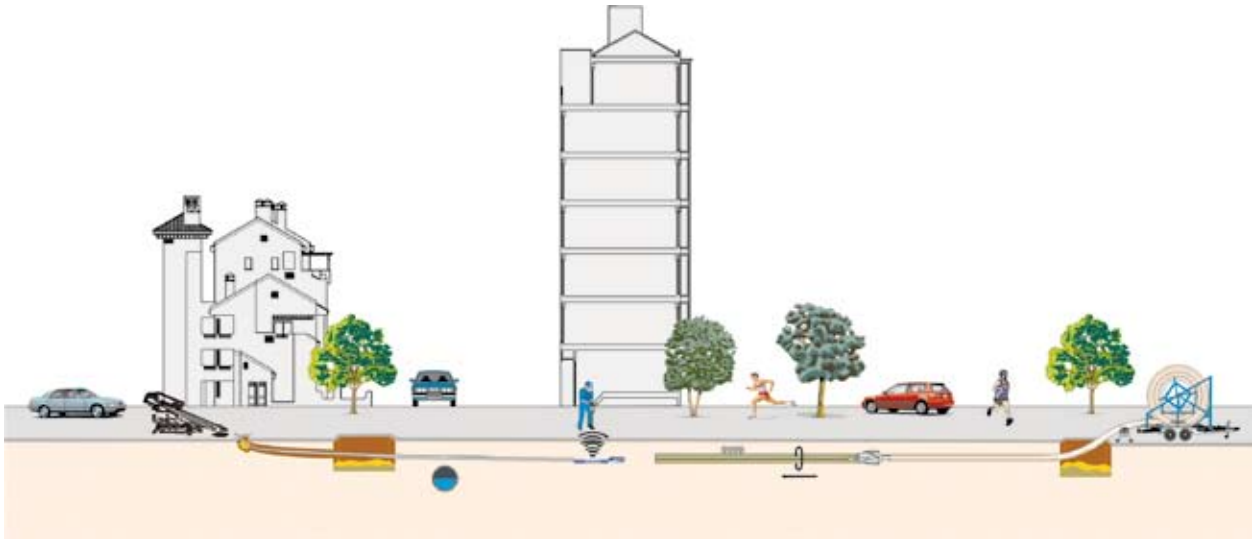
Then, the drill bit is replaced by a reamer which is drawn in the opposite direction by receding from the outlet to the base where the team is positioned, thereby widening the pilot bore.

This operation is repeated several times until it reaches the desired bore diameter.

Step 3: Shooting

A pull head coupled with an anti-rotation joint system is attached to pipe to be drawn. This pull head is then attached to the reamer that performs the last bore widening. This operation is performed gently and slowly to avoid damage to the pipes.

These may contain the drill fluids, such as bentonite or polymers with low environmental impact, but necessary in this case, since they act as a lubricant to reduce friction.



Metro Warsaw Ground Freezing, Warsaw, Poland
Groun Freezing

GROUND FREEZING

Ground consolidation by means of freezing

Freezing as a method of soil immersed into water is a technique known for several decades in the field of geotechnical engineering. Ground freezing can be achieved by the direct (liquid nitrogen) or indirect method (brine). For both systems thermometric data points, placed inside thermometers distributed within the volume to be frozen, allow an indirect control on the formation of the frozen structure.

In the direct method, nitrogen (close to the atmospheric pressure is liquid at a temperature of about -196 ° C) circulates in closed metal pipes causing a thermal shock in the groundwater surrounding the tube itself. Using liquid nitrogen it is possible to freeze the pore water present in a cylinder of soil of about 1 meter diameter within 3-4 days. The liquid nitrogen is distilled from the air and is transported and stored on site in special refrigerated tankers. Once used, the nitrogen is dispersed into the air again as gas.

In the so-called indirect method, brine (a solution of calcium chloride in water) is cooled by means of an electric refrigeration (chilling) unit at temperatures of -35 ° -40 ° C and is circulated in metal tubes placed in the soil (freezing pipes) returning after to the chilling unit to be cooled. In this case it will take about 3-4 weeks to freeze the water present in a cylinder of soil of about 1 meter in diameter. Also in this case the circulating system must be closed, it is essential to avoid any leakage of brine into the ground.

Landslide in Ronda de Barrios. Teruel, Spain
Geotechnical report

ENGINEERING DESIGN

GROUND INVESTIGATION. GEOTECHNICAL REPORTS & CONSULTANCY

TERRATEST is highly experienced at managing, executing and delivering ground investigation projects.
We offer a wide range of sampling and associated field testing techniques, including:

- Cable percussion boring
- Rotary core drilling
- Groundwater monitoring Wells
- Dynamic probing
- Window sampling
- Trial pitting
- Rock excavation trials
- Slit trenching
- Packer permeability testing
- Pump testing
- Soakaway testing
- Shear vane testing
- Gas monitoring & sampling

We operate a comprehensive and modern fleet of rigs and sampling equipment

TERRATEST provides geotechnical interpretative reports (GIR) to consulting engineers and civil engineering contractors. Detailed GIR's have been prepared for a range of schemes including: DIAGONAL MAR, S.A., DECATHLON ESPAÑA, MAKRO AUTOSERVICIO MAYORISTA, THE MILLS GLOBAL, EL CORTE INGLÉS, COMUNIDAD DE MADRID, MINISTERIO DE LA PRESIDENCIA, LAFARGE ASLAND, SIEMENS DIVISION ENERGIA, U.T.E. ACCIONA-COMSA-COPISA, FERROVIAL-AGROMAN, ENDESA, etc... and numerous road project and wind farms. We work closely with consultants and contractors on optimizing foundations.

We also provide geotechnical design services for temporary slope batters, retaining wall structures and piles (pile and retaining wall design is a core element of our consultancy services). Our aim is to provide practical, cost effective and value engineered solutions.

Canelles Dam. Huesca, Spain
Auscultation

AUSCULTATION

What does auscultate mean?

To auscultate is to inform. Only if we have information are we in a position to make reasoned decisions, aimed at solving a problem. Information must be transmitted in a short period of time, to facility the decision making process and, allow us, where appropriate, to take quick action.

Why do we auscultate?

Knowing the response of a structure to different loads, allows us to verify if these responses fall within the design parameters. The sooner we become aware of having exceeded the limits, considered safe, the sooner corrective measures will be undertaken. The result is a safe and costeffective execution of the project.

Auscultation operation description

The purpose of our auscultation system is to facilitate the decision making process by integrating all the process stages, from the choice of instrument to the drafting of the relevant report. The main stages read as follows:

- Choice of the proper instrument
- Installation
- Reading campaigns
- Transmission of information via Internet
- Reports

Building applications

- Retaining works (diaphragm, gravity and ecological walls, etc).
- Facade's verticality.
- Settlements.
- Underpinning control.

Civil work applications

- Excavations.
- Bailing out.
- Slopes.
- Tunnels.
- Reservoirs.
- Retaining works (diaphragm, gravity and ecological walls, etc).
- Roads/ Railways.
- Mining.
- Tests (direct cut on foundations, etc).
- Compensation injections.

Barcelona Subway, Line 9. Barcelona, Spain
Trench cutter

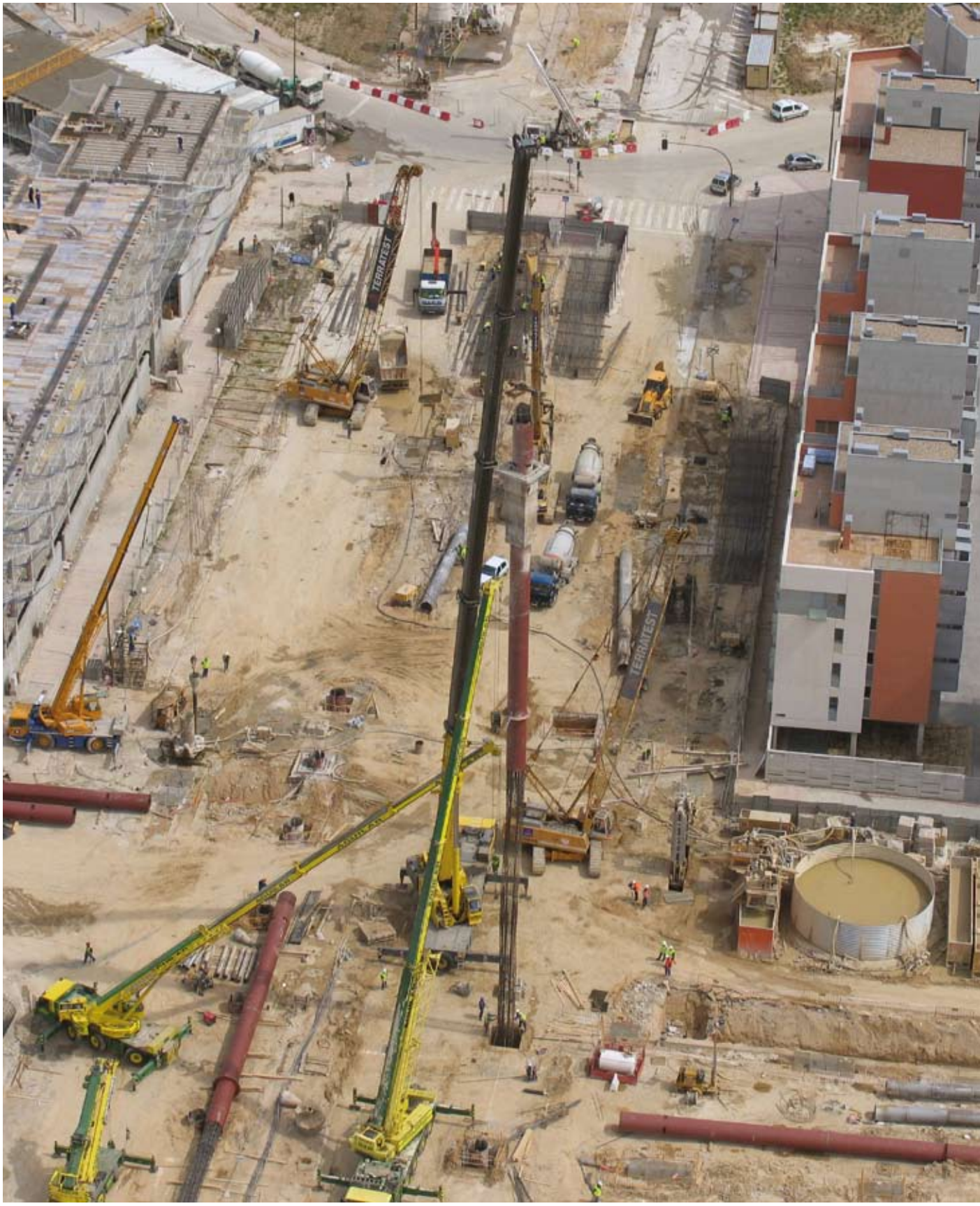
References

More than 500.000 m2 of Diaphragm walls carried out by using Trench Cutter technique

Barcelona Subway, Line 9. Plaza Sanllehy, Barcelona, Spain
Trench Cutter

Botafoc Pier. Ibiza Port, Spain
Bored Piles

North Subway, Stretch 1A. Madrid, Spain
Bored Piles and Diaphragm walls

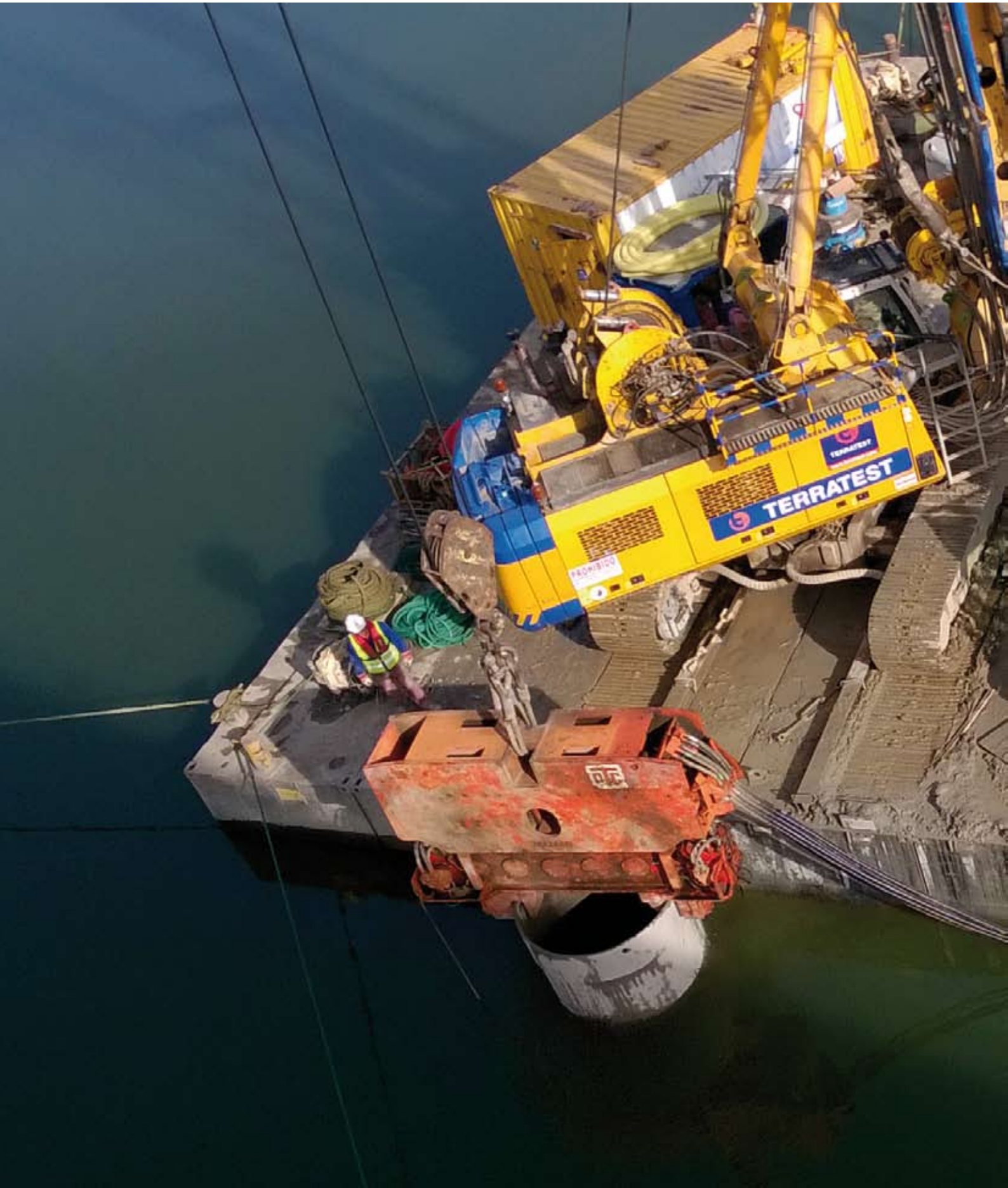


Barcelona Subway, Line 9. Torrassa railway station. Barcelona, Spain
Trench Cutter

Contention works for landslide in A-6 motorway. León, Spain
Ground Anchors

Housing development in Los Barrios. Cádiz, Spain
Stone Columns
Logistic Warehouse in Puerto de Santa María. Cádiz, Spain
Stone Columns

Santa Gertrudis Aquifer. Ibiza, Spain
Soil and aquifers decontamination
A9 Turtmann Cut and Cover Tunnel
Anchored an Jet Grouting Slab


TERRATEST

Castiblanco Bridge, Badajoz, Spain
Bored Piles

First docking frontline prolongation for large ships. Botafoc Dock. Ibiza, Spain
Bored Piles
Retaining wall for excavation pit in Madrid, Spain
Micropiles

Slope stabilization for construction of 15 Villas in Finca Cortesín. Casares. Malaga, Spain
Bored Piles

Madrid-Barcelona-France Border High Speed Railway, Spain
Bored Piles

Bridge Foundation in Maliaño Pier. Santander Port, Spain
Bored Piles

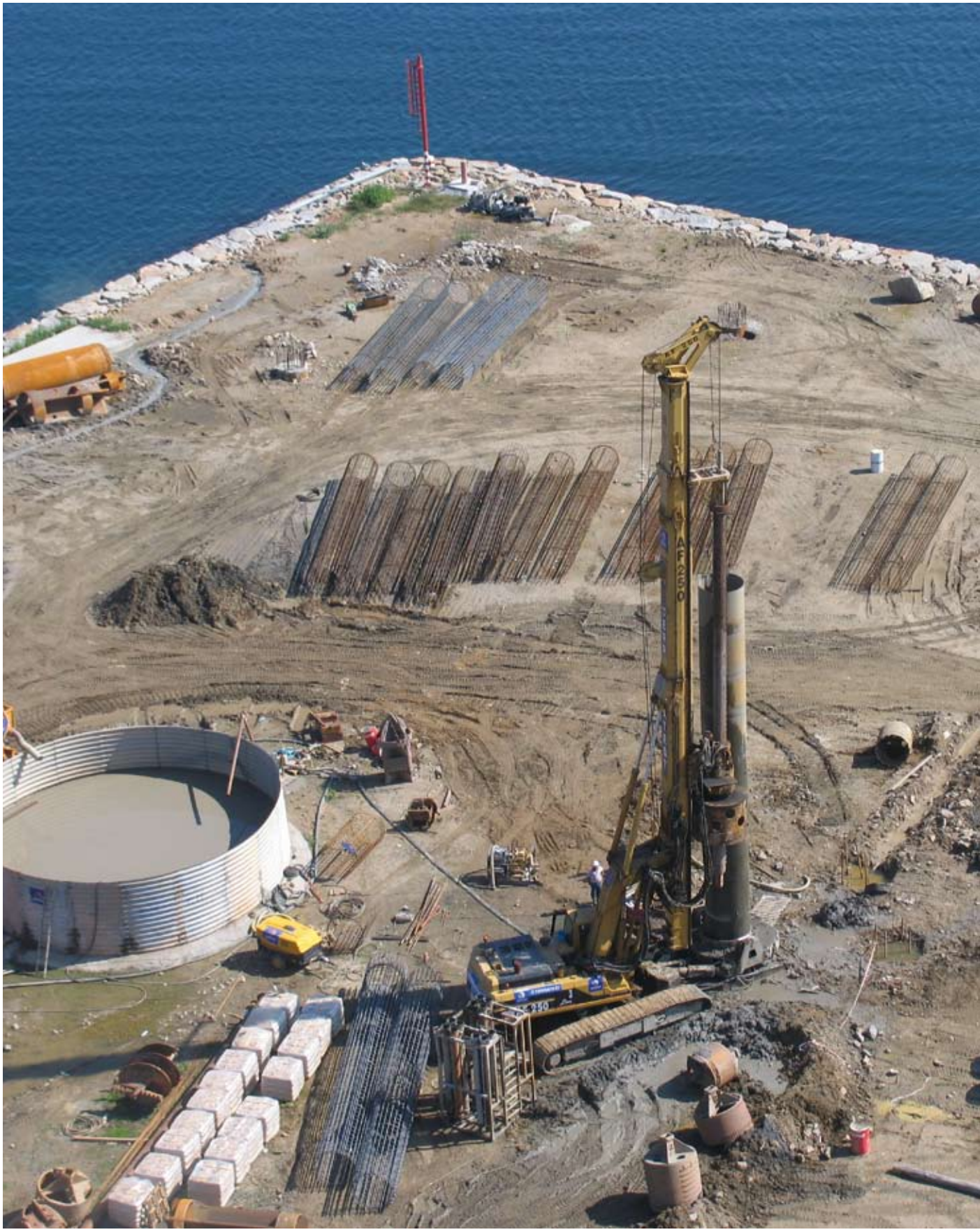
Manzanal Bridge over Ricobayo Dam, Spain
Bored Piles

Development Fase I. Aviles Ria Port
Bored Piles

Gas Natural Combined Cycle Power Plant, Spain
Precast Piles

Corte Inglés Mall, Tarragona, Spain
Diaphragm walls

Coal Power Plant. Medusa Project, Spain
Bored Piles



Residential Building Sotogrande, Cádiz, Spain
Diaphragm walls

Sodermalm Tunnel. Sweden
Tunneling

Kurortni Sochi Beltway, Rusia
Tunneling

Metro M2 Lausanne, Switzerland
Steel Pipe Umbrellas-Jet Grouting

International Bridge over Danube River, connecting
the cities Vidin (Bulgaria) and Calafat (Romania)
Bored Piles

WTC Constant, Romania
Bored Piles

Warsaw Metro, Poland
Diaphragm walls and Jet Grouting

Connection of the Airport with the Maritime Port, Gdansk, Poland
Diaphragm walls and Jet Grouting

Hubertus Tunnel. La Haya-Amsterdam Motorway, La Haya, Holland
Ground Freezing

City Metro Tunnel Karlsruhe Manchette Pipe Grouting
Grouting

2ND Water Power Plant of Honggrin Léman
Rock Grouting

Piedra Larga Wind Farm, Juchitan de Zaragoza, Oxaca, Mexico
Stone Columns

Luis Cabrera Motorway Extension, Mexico City, Mexico
Bored Piles

Edi Wind Farm, Juchitan de Zaragoza, Oxaca, Mexico
Stone Columns

Puente de las Americas Rehabilitation, Panama City, Panama
Ground Anchors

Bellas Artes Subway Station, Santiago De Chile, Chile
Bored piles

On Shore and off Shore Tunnels. Desalination Plant, Sorek, Israel
Tunneling

Talara Refinery Modernization Project. Peru
Precast Piles

Talara Refinery Modernization Project. Peru
Precast Piles

Saint Martin pass. RHÔNE-ALPES - FRANCE
Micropiles
Front face in an excavator open shield
Tunneling

Málaga Subway, Lines 1 and 2. Málaga, Spain
Diaphragm walls
Noth Subway Stretch 1C and 2A. Madrid, Spain
Diaphragm walls
Madrid Subway, Line 3. V. Bajo railway station. Madrid, Spain
Diaphragm walls
Barcelona Subway, Line 9. Barcelona, Spain
Diaphragm walls

Málaga Subway, Line 1. Málaga, Spain
Diaphragm walls
Noth Subway Stretch 2B. Madrid, Spain
Diaphragm walls
Madrid Subway, Line 3. C. Los Ángeles railway station. Madrid, Spain
Diaphragm walls
Barcelona Subway, Line 9. Barcelona, Spain
Diaphragm walls








References

Marina La Farola Málaga Harbour, Spain
Diaphragm walls and Anchors
Foundations for a new Drawbridge. Santander Harbour, Spain
Bored Piles
Juan Gonzalo Dock. Huelva Harbour, Spain
Compaction Grouting, Jet Grouting
El Prat Dock. Barcelona, Spain
Stone Columns

Coal warehouse. La Coruña, Spain
Bored Piles
Silos. Tarragona Harbour, Spain
Precast Piles
New fish market. La Coruña, Spain
Micropiles
Avilés Estuary. Asturias, Spain
Bored Piles








Burkina Faso Embassy in Abidjan, Ivory Coast
Bored piles


LIFE VEST MUST
BE WORN BEYOND
THIS POINT

SSAGS Project. Bayelsa. Nigéria
Precast piles

Road RN6 Tanaff Kolda Lot 1, Lot 2 and Kolda Bridge, Senegal
Bored piles

SUNTI Golden Sugar Estate, Mokwa,
Niger State, Nigeria
CFA Piles

Sede FIRS. Abuja, Nigeria
Bored Piles

References

PILES

PROJECT	COUNTRY	CLIENT	TECHNIQUE
CONSTANTINE TRAMWAY	ALGELIA	FONDAZIONI ESPACIALI, S.P.A. (P00FGX)	CFA
ANNABA BRIDGE	ALGELIA	LEVANTINA INGENIERIA Y CONSTRUCCIONES	BORED PILES
INMIGRANTES HIGHWAY SP-160. SECTION SAO PAULO - SANTOS	BRAZIL	FERREIRA GUEDES	PRECAST PILES
DOUBLE ROAD BRIDGES LOBOGUERRERO - CISNEROS	COLOMBIA	CONSORCIO SSC CORREDORES PRIORITARIOS	BORED PILES
DOCK STRUCTURE IN DRUMMOND PORT	COLOMBIA	EQUIPOS E INGENIERÍA S.A.	BORED PILES
TCBUEN DOCK MODULE REPAIR	COLOMBIA	COPISA	BORED PILES
PLAZA CENTRAL MALL	COLOMBIA	COLPATRIA S.A.	BORED PILES
KARIBANA HILTON HOTEL IN CARTAGENA	COLOMBIA	INMOBILIARIA KARIBANA S.A.S.	CFA
FUEL TANKS FOR SOLMICO OIL S.A.S. PHASE III	COLOMBIA	SOLMICO OIL S.A.S.	PRECAST PILES
PORT OF SANTA MARTA	COLOMBIA	EQUIPOS E INGENIERIA	CFA
SORTIE NORD - BRIDGE FOUNDATION	CONGO	SGE-CONGO	BORED PILES
OFFICIAL BUILDING PILE FOUNDATION	CONGO	AB CONSTRUCCION	CFA
BENIN EMBASSY PARKING	CONGO	PANORAMA	CFA
MILITARY HOSPITAL IN BRAZZAVILLE	CONGO	AMS	BORED PILES
BANNDAMA BRIDGE	IVORY COAST	COLAS AFRIQUE	BORED PILES
CHAÎNE HOTEL IN ABIDJAN	IVORY COAST	TEILYOM	BORED PILES
BURKINA FASSO EMBASSY BUILDING	IVORY COAST	DECOTEK	BORED PILES
TRONÇONT BLV. LATRILLE	IVORY COAST	SOROUBAT	BORED PILES
BATÎMENT ZONE 4	IVORY COAST	ERDOGAN CONSTRUCTION	BORED PILES
COOPESA HANGAR	COSTA RICA	FCC CONSTRUCCION DE CENTROAMERICA, S.A.	BORED PILES
HIGHWAY R2 ZVOLEN VYCHOD - PRUTSA	SLOVAKIA	CORSÁN-CORVIAM CONSTRUCCIÓN, S.A.	BORED PILES
A-8 HIGHWAY, SECTION: SOLARES - LA ENCINA	SPAIN	UTE LA LLAMA	PRECAST PILES
PENITENTIARY IN TERUEL	SPAIN	UTE AMPLIACION CENTRO PENITENCIARIO TERUEL	PRECAST PILES
RESIDENTIAL BUILDING IN SANTO ANGEL. MURCIA	SPAIN	PEREZ CANOVAS	PRECAST PILES
RESIDENTIAL BUILDING IN CALPE. MURCIA	SPAIN	CIVINED	PRECAST PILES
FLUVIAL WALK/PROMENADE AT ODIEL SEA INLET(HUELVA)	SPAIN	OHL	PRECAST PILES
WASTEWATER TREATMENT PLANT IN LA ANTILLA(HUELVA)	SPAIN	JOCA	PRECAST PILES
REHABILITATION CENTER	SPAIN	CNES FELIPE CASTELLANOS	PRECAST PILES
OFFICE BUILDING IN GIBRALTAR	SPAIN	GJBS	PRECAST PILES
CONSUM LOGISTICS WAREHOUSE	SPAIN	CONSUM	PRECAST PILES
REFRIGERATED WAREHOUSE IN SAN ISIDRO	SPAIN	ALMACEN FRIOGORIFICO SAN ISIDRO	PRECAST PILES
"THE STYLE OUTLET" SHOPPING CENTRE IN VILADECANS	SPAIN	SACYR	PRECAST PILES
HIGH SPEED RAILWAY ACCESS TO THE CITY OF ALICANTE	SPAIN	ALDESA CNES	BORED PILES
A-3 HIGHWAY, SECTION: BUÑOL - VALENCIA	SPAIN	UTE A3 BUÑOL-VALENCIA(CLEOP-OH	BORED PILES
A-15 HIGHWAY, SECTION: MEDINACELLI - RADONA	SPAIN	ACCIONA	BORED PILES
A-8 HIGHWAY, SECTION: SOLARES - LA ENCINA	SPAIN	FCC CONSTRUCCIÓN	BORED PILES
EMERGENCY WORKS ON A-44 HIGHWAY	SPAIN	ACCIONA	BORED PILES
BAUHAUS MALL	SPAIN	CNES BERTOLIN	BORED PILES
PILE RETAINING WALL IN SECONDARY ROAD CP-563 IN SALAMANCA	SPAIN	DIPUTACIÓN PROVINCIAL SALAMANCA	BORED PILES
RAIL BEAM FOR THE EAST DOCK CRANE. PORT OF VALENCIA	SPAIN	UTE DRAGADOS - PAVASAL	BORED PILES
STAGE II CONTAINAR TERMINAL IN PORT OF BARCELONA	SPAIN	UTE FCC-OHL(UTE ZONA MANIOBRA)	BORED PILES
WALL REPAIR ON N-362 ROAD	SPAIN	FERROVIAL AGROMAN	BORED PILES
EL SAUCE II RESIDENTIAL BUILDING	SPAIN	MYRAMAR	BORED PILES
CARBAIO-BEDOIAS HIGHWAY	SPAIN	UTE COSMO	BORED PILES
EMERGENCY WORKS ON N-420, PK 98	SPAIN	MATINSA	BORED PILES
RAIL BEAM FOR THE CRANE IN NAVANTIA PORT	SPAIN	FONSAN	PRECAST PILES
EMERGENCY ON N-340 PASSING THROUGH ALFAMAR RESIDENTIAL AREA	SPAIN	MINISTERIO FOMENTO-DEMAR. DE CARRETERAS	BORED PILES
SANT ANTONI MARKET IN BARCELONA	SPAIN	FCC CONSTRUCCION,S.ACATALUNYA EDIFICACION	BORED PILES

References

PILES

PROJECT	COUNTRY	CLIENT	TECHNIQUE
A7 HIGHWAY. SECTION TARAMAY - LOBRES IN GRANADA	SPAIN	FCC CONSTRUCCIÓN	BORED PILES
LA SAGRERA STATION STRUCTURE	SPAIN	UTE DRAGADOS-ACCION-COMSA-ACSA	BORED PILES
HIGH SPEED RAILWAY,SECTION: ANTEQUERA-PEÑA ENAMORADOS	SPAIN	ACCIONA INFRAESTRUCTURAS, S.A.	BORED PILES
HIGH SPEED RAILWAY, SECTION MADRID- TORREJON DE VELASCO	SPAIN	ALDESA CONSTRUCCION S.A.	CFA
DRAGADOS OFF SHORE FACILITIES	SPAIN	DRAGADOS OFFSHORE, S.A.	CFA
LUIS CABRERA BRIDGE IN MEXICO CITY	MEXICO	OHL-COPRY	BORED PILES
PAJARITOS COGENERATION POWER PLANT IN COATZACOALCOS	MEXICO	OHL-SENER	BORED PILES
ANDAMAR MALL IN BOCA DEL RIO, VERACRUZ	MEXICO	OSM	BORED PILES
LIBRAMIENTO DE VILLAHERMOSA RINGROAD LA PIGUA IN TABASCO	MEXICO	MOTA ENGIL	BORED PILES
ONE HOTEL IN VILLAHERMOSA, TABASCO	MEXICO	CONSTRUCTORA Y PROMOTORA MALIBRAN	BORED PILES
JALA MALL IN COMPOSTELA	MEXICO	GIA	BORED PILES
BRIDGE IN VILLAHERMOSA ROAD, STA 162-962	MEXICO	MOTA ENGIL	BORED PILES
BRIDGE IN VILLAHERMOSA ROAD. SECTION NACAJUCA	MEXICO	TRISIMEX	BORED PILES
TOLUCA TRAIN BRIDGE. SECTION 3 OBSERVATORIO	MEXICO	MOTA ENGIL	BORED PILES
DOMINICA II PROJECT	MEXICO	GES	BORED PILES
NORTHERN URBAN HIGHWAY MEXICO CITY	MEXICO	OHL	BORED PILES
VILLAHERMOSA RINGROAD HIGHWAY IN TABASCO	MEXICO	ACCIONA MEXICO	BORED PILES
SSAGS SHELL REFINERY	NIGERIA	EVOMEC GLOBAL SERVICES LTD	PRECAST PILES
SUNTI GOLDEN SUGAR ESTATE	NIGERIA	FLOUR MILLS OF NIGERIA PLC	CFA
BADAGRY BRIDGE IN LAGOS	NIGERIA	CCECC	BORED PILES
BRIDGE IN GURARA ROAD	NIGERIA	SCC	BORED PILES
PILE RETAINING WALL IN WEMPCO'S FACTORY	NIGERIA	WEMPCO STEEL MILL LIMITED	BORED PILES
ILLUBIRIN PROJECT IN LAGOS	NIGERIA	MAK&MAK	PRECAST PILES
FERTILIZER PLANT, DANGOTE (LAGOS))	NIGERIA	DANGOTE FERTILIZER LIMITED	PRECAST PILES
BOUYGUES NIG LTD HEADQUARTERS	NIGERIA	BOUYGUES NIGERIA LTD	BORED PILES
SEWERAGE WELLS FOR LA BAHIA, CINTA COSTERA	PANAMA	ODEBRECHT	BORED PILES
PH MAREAS BEACH RESIDENTIAL BUILDING	PANAMA	CEREBROS INGENIEROS	PRECAST PILES
DAKA WELL FOR IGUANA SEWERAGE	PANAMA	ODEBRECHT	BORED PILES
PH CARRERAS TOWER PROJECT	PANAMA	GRUPO CARRERAS	BORED PILES
"BY RESIDENCE "RESIDENTIAL BUILDING	PANAMA	LADD CONTRATISTAS S.A.	BORED PILES
RECOMISSION AND CONSTRUCTION OF THE VIA BRASIL CORRIDOR	PANAMA	FCC CONSTRUCCION DE CENTRO AMERICA	BORED PILES
SCUT AZORES HIGHWAY	PORTUGAL	FERROVIAL AGROMAN	BORED PILES
CONVENTION CENTER - CONVENTO SAN FCO	PORTUGAL	MRG-MANUEL RODRIGUES GOUVEIA	BORED PILES
COINA 1 - IC32 BRIDGE	PORTUGAL	ZAGOPE CONSTRUCTORA INGENIERIA S.A.	BORED PILES
RIBEIRA DAS NAUS AVENUE RESTORATION	PORTUGAL	SETH	BORED PILES
ARADA SPORTS CENTER	PORTUGAL	JOAO CABRAL GONCALVES E FILHOSLDA	CFA
PARKING STRUCTURE P4 FCO CARNEIRO AIRPORT	PORTUGAL	HCI-CONSTRUÇOES, S.A.	CFA
LOGISTICS PLATFORM ACCESS NORTHERN LISBON	PORTUGAL	SOARES DA COSTA	PRECAST PILES
PARQUE SUSTENTABILIDADE-PDS	PORTUGAL	CONSTRUÇOES EUROPA AR-LINDO, S.A.	PRECAST PILES
EB 2,3 PEDRO JACQUES MAGALHAES	PORTUGAL	HCI-CONSTRUÇOES, S.A	PRECAST PILES
INSURATEI, CUZA VODA AND SCHIELA WIND FARMS	ROMANIA	GLOBAL WIND POWER	BORED PILES
PECHEA WIND FARM	ROMANIA	MARTIFER	BORED PILES
BABADAG WIND FARM	ROMANIA	LUCAPREST	BORED PILES
RN6 TANAFF-KOLDA ROAD	SENEGAL	ISOLUX CORSAN CORVIAM	BORED PILES

References

EXCAVATION SUPPORT

PROJECT	COUNTRY	CLIENT	TECHNIQUE
LINE 5 FOR SAO PAULO METRO	BRAZIL	MENDES JUNIOR	DIAPHRAGM WALLS
DOCKYARD IN RIO GRANDE DO SUL PORT	BRAZIL	COMSA/GPO	DIAPHRAGM WALLS
116 HIGHWAY . SECTION SAO PAULO - CURITIBA	BRAZIL	COMSA EMTE	SOIL NAILING
CRESPO TUNNEL	COLOMBIA	EQUIPOS E INGENIERÍA S.A.	DIAPHRAGM WALLS
MERCURIO PROJECT	COLOMBIA	TERRANUM CORPORATIVO S.A.	DIAPHRAGM WALLS
PLAZA CENTRAL SHOPPING CENTER	COLOMBIA	COLPATRIA S.A.	DIAPHRAGM WALLS
COMUNEROS CANAL	COLOMBIA	CONSORCIO CANALES ZONA 3	DIAPHRAGM WALLS
MEDELLIN RIVER PARK	COLOMBIA	AGRUP. GUINOVART OBR. Y SERV. HISPANIA S.A.	DIAPHRAGM WALLS
SANTA MARTA AIRPORT	COLOMBIA	CONTEIN S.A.S.	DIAPHRAGM WALLS
LA SABANA MEDICAL CENTER	COLOMBIA	CONTEIN S.A.S.	DIAPHRAGM WALLS
F.U. LOS LIBERTADORES	COLOMBIA	GUTIERREZ DÍAZ Y CIA S.A	DIAPHRAGM WALLS
A7 HIGHWAY. SECTION PUNTALON - CARCHUNA	SPAIN	ACCIONA INFRAESTRUCTURAS	GROUND ANCHORS
AMOREBIETA-ETXANO GREEN WALL	SPAIN	CORSAN CORVIAM CONSTRUCCION	GROUND ANCHORS
HIGH SPEED RAILROAD SECTION SAGRERA-NUDO TRINIDAD	SPAIN	CORSAN - CORVIAM	GROUND ANCHORS
FLAMENCO CITY IN JEREZ	SPAIN	SACYR SAU	GROUND ANCHORS
LA LOTETA DAM LEFT ABUTMENT WATERPROOFING	SPAIN	CONFEDERACION HIDROGRAFICA DEL EBRO	TRENCH CUTTER
SANT ANTONI MARKET REMODELLING	SPAIN	SACYR S.A.U.	TRENCH CUTTER
HIGH SPEED RAILWAY ACCESS TO THE CITY OF ALICANTE	SPAIN	ALDESA	TRENCH CUTTER
NEW WASTEWATER TREATMENT PLANT PEÑISCOLA	SPAIN	UTE DRAGADOS - ASEDES	DIAPHRAGM WALLS
LAGARES WASTEWATER TREATMENT PLANT	SPAIN	UTE EDAR LAGARES (OHL-CORSAN CORVIAM)	DIAPHRAGM WALLS
SON COLOM WINERY	SPAIN	UTE SON GENER VELL- MERCHOR MASACARO	DIAPHRAGM WALLS
MERCADONA SUPERMARKET	SPAIN	NORCONTRATAS	DIAPHRAGM WALLS
UREMA RIVER CHANNELLING	SPAIN	HNOS ELORTEGUI	DIAPHRAGM WALLS
RESIDENTIAL BUILDING	SPAIN	CONSTRUCCIONES FELIPE CASTELLANO	DIAPHRAGM WALLS
PUERTO DE TRIANA MALL & OFFICES BUILDING	SPAIN	AYNOVA, S.A.	DIAPHRAGM WALLS
HIGH SPEED RAILWAY. SEC. ORIHUELA - COLADA DE LA BUENA VIDA	SPAIN	UTE SACYR-NEOPUL	DIAPHRAGM WALLS
MALL ENLARGEMENT IN BARCELONA STREET	SPAIN	EL CORTE INGLES, S.A.	DIAPHRAGM WALLS
HIGH SPEED RAILROAD SECTION MONTORNES-LA ROCA	SPAIN	UTE MONTMELO	DIAPHRAGM WALLS
LA SAGRERA STATION STRUCTURE	SPAIN	UTE DRAGADOS-ACCIONA-COMSA-ACSA	DIAPHRAGM WALLS
VALLADOLID RAILWAY CONNECTION	SPAIN	UTE VARIANTE ESTE VALLADOLID	DIAPHRAGM WALLS
HIGH SPEED RAILROAD SECTION MONTCADA-MOLLET	SPAIN	CONSTRUCTORA SAN JOSE, S.A.	TRENCH CUTTER
XALAPA HIGHWAY	MEXICO	ISOLUX CORSAN – MOTA ENGIL	SOIL NAILING
EL ALTO Y MONTELIRIO DAM	PANAMA	HIDRÁULICA DEL CHUIRIQUÍ, S.A.	INJ. AND BENT. SLURRY WALLS
LINE 2 FOR WARSAW METRO	POLAND	AGP METRO POLSKA	DIAPHRAGM WALLS
POZNAN-WROCLAW RAILROAD STA 145+162	POLAND	FCC CONSTRUCCIÓN - DECOMA	DIAPHRAGM WALLS
MEGA MALL BUCAREST	ROMANIA	ELJ VATRA	DIAPHRAGM WALLS
UNITED BUSINESS CENTER 5	ROMANIA	BUILD CORP	DIAPHRAGM WALLS
LINE M5 FOR WARSAW METRO	ROMANIA	ELJ VATRA SRL	DIAPHRAGM WALLS
METRO MAGISTRALA 5	ROMANIA	CON. ASTALDI – FCC- DELTA ACM . AB CONSTRUCT	DIAPHRAGM WALLS
TRAJANO BRIDGE RESTORATION	ROMANIA	C&C MH CONFORT	DIAPHRAGM WALLS
PARKING IN INDEPENDENCE SQUARE IN DAKAR	SENEGAL	CDE	DIAPHRAGM WALLS

References

MICROPILES

PROJECT	COUNTRY	CLIENT	TECHNIQUE
ISLAS SECAS HOTEL	PANAMA	PACIFIC PANAMA SOLUTIONS S.A.	MICROPILES
PANAMA CANAL BLASTING BOREHOLES	PANAMA	TREVY PANAMA	MICROPILES
ESPOIR HOSPITAL	IVORY COAST	CABINET ACA	MICROPILES
POBLENOU STATION ACCESSES FOR LINE 4	SPAIN	COPISA	MICROPILES
TELNET WAREHOUSE IN CENTROVIA INDUSTRIAL SITE	SPAIN	ARQUIEM	MICROPILES
SANTA MARIA MAGDALENA CHURCH	SPAIN	JOAQUIN PEREZ ARROYO S.L.U.	MICROPILES
RESIDENTIAL BUILDING IN EL VISO, MADRID	SPAIN	FATECSA OBRAS SA	MICROPILES
DE LA OSA DOCK RO-RO RAMP	SPAIN	OHL	MICROPILES
AALTO WINE CELLAR RECONSTRUCTION	SPAIN	CONSTRUCTORA SAN JOSE	MICROPILES
VILLANOVILLA BUILDING	SPAIN	FONDO COLECTIVO DE AHORRO, S.L.	MICROPILES
TEMPLE PALACE RESTORATION	SPAIN	ACCIONA INFRAESTRUCTURAS, S.A.	MICROPILES
BRIDGE OVER THE VERO RIVER	SPAIN	PRYOBRAS 2010, S.L.	MICROPILES
SLOPE STABILIZATION AND CHANNEL REPAIRING	SPAIN	BECSA	MICROPILES
"PATIO DE LOS NARANJOS" IN SEVILLE CATHEDRAL	SPAIN	PROYECTOS Y REHABILITACION KALAM, S.A.	MICROPILES
DULA INVEST WAREHOUSE PHASE II	SPAIN	DULA ESPAÑA	MICROPILES
CONSUM LOGISTICS WAREHOUSE. PHASE III	SPAIN	COSUM SOCIEDAD COOPERATIVA	MICROPILES
SA RIERA HOTEL	SPAIN	LATOX2J, S.L.	MICROPILES
DERIVADOS CALCICOS PONT MAJOR	SPAIN	CONSTRUCCIONES RUBAU	MICROPILES
SEAWAGE PIPE RESTORATION IN ESTEIRO	SPAIN	EUROHINCA (EUROPEA DE HINCA TELEDIRIGIDA, S.A.)	MICROPILES
THERMAL POWER PLANT	SPAIN	TSK	MICROPILES

TUNNELING

PROJECT	COUNTRY	CLIENT	TECHNIQUE
CEYRANBATAN Project - DN1600	AZERBAIJAN	HIDROLOTUS	TUNNELING
TUNNEL LIEFKEN SHOEK	BELGIUM	JV VINCI WAYSS&FREYTAG, CEI, MBG	GROUND FREEZING
IVECO PEGASO - DN1500	SPAIN	BYCO, S.A.,	TUNNELING
VALMENOTRE-GALLERIA MUCCIA	ITALY	ITALTUNNEL	TUNNELING
TUNEL EJERCITO MEXICANO LINEA 1	MEXICO	GRUPO PROMOTOR TAMULIPAS	TUNNELING
TUNEL EJERCITO MEXICANO LINEA 2	MEXICO	GRUPO PROMOTOR TAMULIPAS	TUNNELING
TUNNEL SLUISKIL	NETHERLANDS	ARGE BAM-TBI	GROUND FREEZING
INSPECCION TUNELADORA DE PANDO	PANAMA	EISA	TUNNELING
C13 - POWISLE STATION	POLAND	AGP METRO	GROUND FREEZING
V15 - VENTILATION SHAFT	POLAND	AGP METRO	GROUND FREEZING
V14 - VENTILATION SHAFT	POLAND	AGP METRO	GROUND FREEZING
GDANSK	POLAND	OHL	GROUND FREEZING
AL KHOR SEWERAGE	QATAR	LOTUS TRADING & CONTRACWING	TUNNELING
THIRD PARTY INTERCONECWION FACILITIES	QATAR	LARSEN & TOUBRO	TUNNELING
AL KHEESA SEWERAGE EXTENSION	QATAR	COMBINED GROUP & SACYR JV	TUNNELING
UPGRADE OF MESAIEED TOWN RPS - GTC 444/2011	QATAR	AL JABER ENGINEERING	TUNNELING
VILLAGARCIA DE AROSA-CATOIRA	SPAIN	UTE CATOIRA (ACCIONA-OSSA)	TUNNELING
LAV LEGORRETA	SPAIN	UTE LEGORRETA(ACCIONA-VDA SAIN(ACCIONA-VDA SAINZ)	TUNNELING
IMPERM.TÚNEL PAJARES NORTE (O)	SPAIN	UTE IMPERM.TÚNEL PAJARES NORTE(ACCIONA-FCC)	TUNNELING
LAV ASPE-EL CARRÚS(ALICANTE)	SPAIN	UTE ASPE CARRÚS (PAVASAL-NORTU (PAVASAL-NORTUNEL)	TUNNELING
VACARIZA-RIALIÑO(LA CORUÑA)	SPAIN	UTE VACARIZA RIALIÑO	TUNNELING
LAV ARCHIDONA-ARROYO NEGRA	SPAIN	UTE TÚNEL ARCHIDONA(DRAGADOS-TECSA)	TUNNELING
RENOVACIÓN CORTES-SAN PABLO	SPAIN	UTE CORTES-SAN PABLO (ACCIONA-COMSA)	TUNNELING

References

GROUND IMPROVEMENT

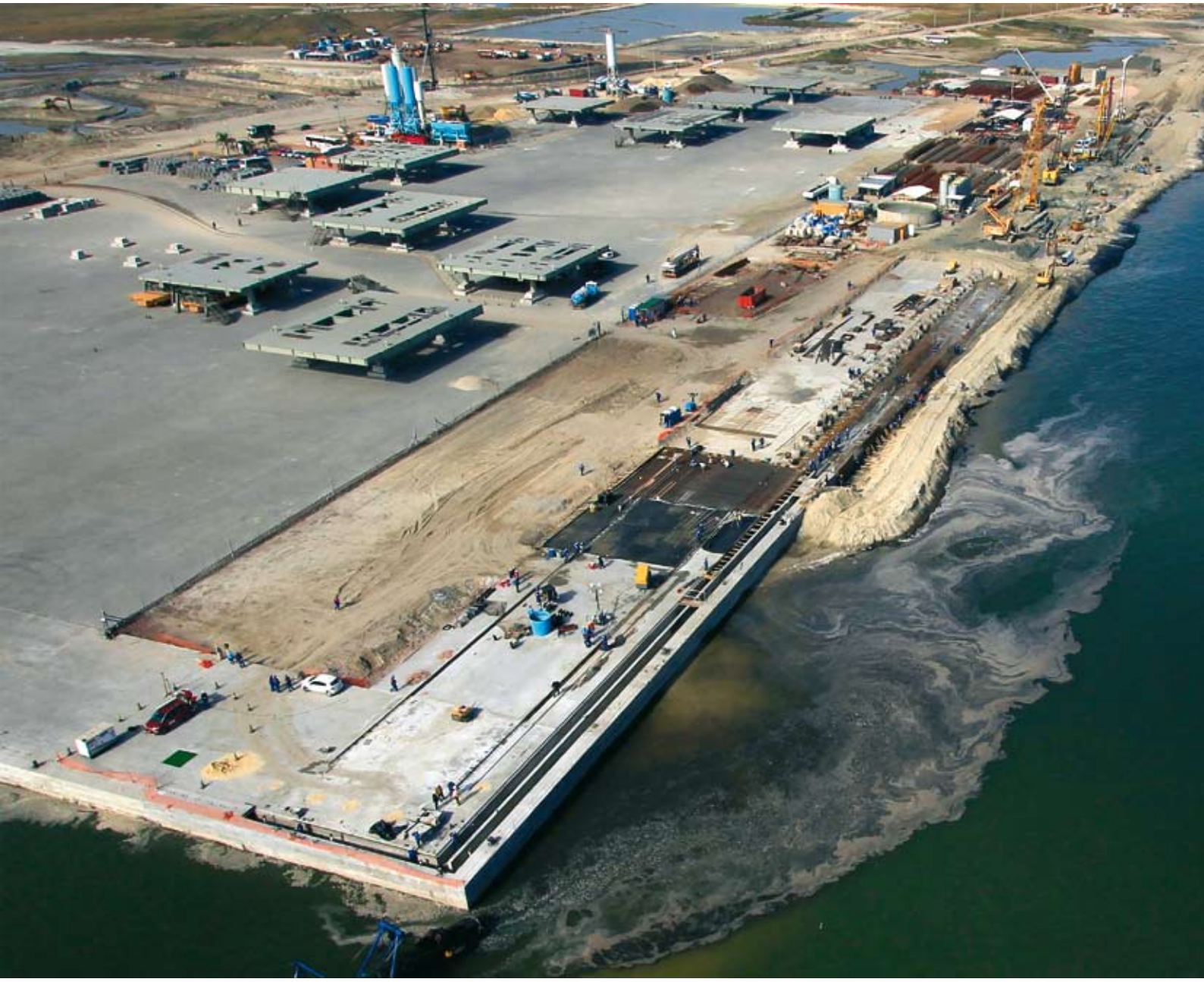
PROJECT	COUNTRY	CLIENT	TECHNIQUE
UMFAHRUNG OST	AUSTRIA	ARGE TUNNELBAU UMFAHRUNG LAMBACH OST	JET GROUTING
RÉGIS BITTENCOURT – LOTE 3	BRAZIL	OSSA	WICK DRAINS
DOCK RESTORATION	CHILE	ACS GROUP, COMSA and BESALCO	OFF-SHORE STONE COLUMS
INDUSTRIAL WAREHOUSE 45-48 ZOL FUNZA	COLOMBIA	TERRANUM CORPORATIVO S.A.	VIBROCOMPACTION/STONE COLUMNS
CHUCAS DAM TREATMENTS	COSTA RICA	FCC	GROUTING
RENACE II DAM	COSTA RICA	FCC CONSTRUCCION DE CENTROAMERICA, S.A.	GROUTING
RAILWAY CONNECTION. BILBAO PORT - PANCORBO	SPAIN	UTE PANCORBO	WICK DRAINS
CONTAINERS TERMINAL IN CADIZ PORT	SPAIN	UTE NTC CADIZ	WICK DRAINS
REINFORCEMENT IN DOCK NUMBER 3. ALGECIRAS PORT	SPAIN	AP BAHIA ALGECIRAS	GROUTING
HIGH SPEED RAILWAY CASTEJÓN- CADREITA.	SPAIN	UTE CASTEJON-CADREITA	WICK DRAINS
PISUERGA STREET EXTENSION	SPAIN	COPCISA	JET GROUTING
OAXACA WIND FARM	MEXICO	GAMESA	VIBROCOMPACTION/STONE COLUMNS
BII-HIOXO WIND FARM IN OAXACA	MEXICO	GAMESA	VIBROCOMPACTION/STONE COLUMNS
PIEDRA LARGA II WIND FARM IN OAXACA	MEXICO	GAMESA	VIBROCOMPACTION/STONE COLUMNS
DOS ARBOLITOS WIND FARM	MEXICO	GAMESA	VIBROCOMPACTION/STONE COLUMNS
ALTO DAM	PANAMA	HIDRÁULICAS DE EL ALTO (GRUPO COBRA-ACS)	GROUTING
BAJO FRÍO DAM	PANAMA	FCC CENTROAMÉRICA, S.A. BAJO-FRIO	GROUTING
PEDREGALITO DAM	PANAMA	PANAMA POWER HOLDING	GROUTING
HIGH SPEED RAILWAY MALLORCA-PADILLA	SPAIN	UTE LA SAGRERA (SACYR-CAVOSA-SCRINSER)	JET GROUTING
DRAUGHT ENLARGEMENT IN ARAGON DOCK	SPAIN	FCC	JET GROUTING
FISHING DOCK REPARATION	SPAIN	FERROVIAL AGROMAN S.A.	JET GROUTING
BILBAO METRO LINE 3	SPAIN	UTE CYCASA-NORTUNEL-COMSA	JET GROUTING
CAMPO DE DALIAS DESALINATION PLANT	SPAIN	UTE DESALADORA CAMPO DE DALIAS	JET GROUTING
RAILWAY CAMAS-SALTERAS	SPAIN	UTE CAMAS - SALTERAS	COMPACTION GROUTING
ACCESS IMPROVEMENT TO SANTS RAILWAY STATION	SPAIN	VIAS Y CONSTRUCCIONES S.A.	COMPACTION GROUTING
HIGH SPEED RAILWAY NEW ACCESS TARANCON-UCLES	SPAIN	UTE TARANCON UCLES	COMPACTION GROUTING
ESPARTERO PALACE REHABILITATION	SPAIN	ORTIZ CNES. Y PROYECTOS, S. A.	COMPACTION GROUTING
BARRANCO SECO WASTE WATER TREATMENT PLANT	SPAIN	VVO CONSTRUCCIONES Y PROYECTOS, S.A.	COMPACTION GROUTING
TUNNEL SÖDERMAL	SWEDEN	ZÜBLIN SCANDINAVIA	JET GROUTING AND MICROPILES
TRAVAUX LACUSTRES	SWITZERLAND	CONSORTIUM TRAVAUX LACUSTRE ST. GINGOLPH	JET GROUTING
LOT25.11 - TUNNEL DE CHAMPEL	SWITZERLAND	CTC - CONSORTIUM TUNNEL DE CHAMPEL	JET GROUTING
A9 HIGHWAY (BETWEEN SION AND VISP)	SWITZERLAND	PRADER LOSINGER, FRUTIGER	JET GROUTING AND GEWI ANCHORAGES

References

ENVIRONMENTAL WORKS

PROJECT	COUNTRY	CLIENT	TECHNIQUE
DEPÓSITO HIDROEÓLICO EL HIERRO	SPAIN	DEPÓSITO CENTRAL HIDROEÓLICAUTE	WATER RESERVOIRS
BALSA TERMOSOLAR OLIVENZA	SPAIN	UTE TERMOSOLAR OLIVENZA	WATER RESERVOIRS
BALSA CENTRAL TERMICA TERUEL	SPAIN	ENDESA GENERACIÓN	WATER RESERVOIRS
BALSA LA CALDERETA	SPAIN	UTE BALSA LA CALDERETA	WATER RESERVOIRS
IMP. BALSA PUENTENUEVO	SPAIN	EXCAVACIONES LEAL	WATERPROOFING
BALSA BOADILLA DEL MONTE	SPAIN	SACYR	WATER RESERVOIRS
IMP. BALSA ALLOZAR	SPAIN	MALLORCA CASTILLO DE VIÑUELAS	WATERPROOFING
DIQUE DEL VASO DE SALINAS	SPAIN	POTASAS DE SUBIZA , S.A. (POSUSA)	WATER RESERVOIRS
BALSA CERROJA	SPAIN	DIPUTACIÓN FORAL DE BIZKAIA	WATER RESERVOIRS
NISSAN FACTORY	SPAIN	NISSAN FORKLIFT ESPAÑA , S.A	SOIL DECONTAMINATION
TRANSFORM ENDESA	SPAIN	GRUPO SOLER	SEALING AND DEGASSING OF LANDFILLS
PROY. OBRA SON REUS	SPAIN	EMAYA	SEALING AND DEGASSING OF LANDFILLS
DEPOSITO SEGURIDAD III Y IV	SPAIN	TIRME	SEALING AND DEGASSING OF LANDFILLS
SELLADO VERT CAL GITANET	SPAIN	UTE CAL GITANET	SEALING AND DEGASSING OF LANDFILLS
VERTEDERO PUNTAL DEL BUHO ELCH	SPAIN	CLEOP, S.A.	SEALING AND DEGASSING OF LANDFILLS

Açu Port, Brazil
Diaphragm walls



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