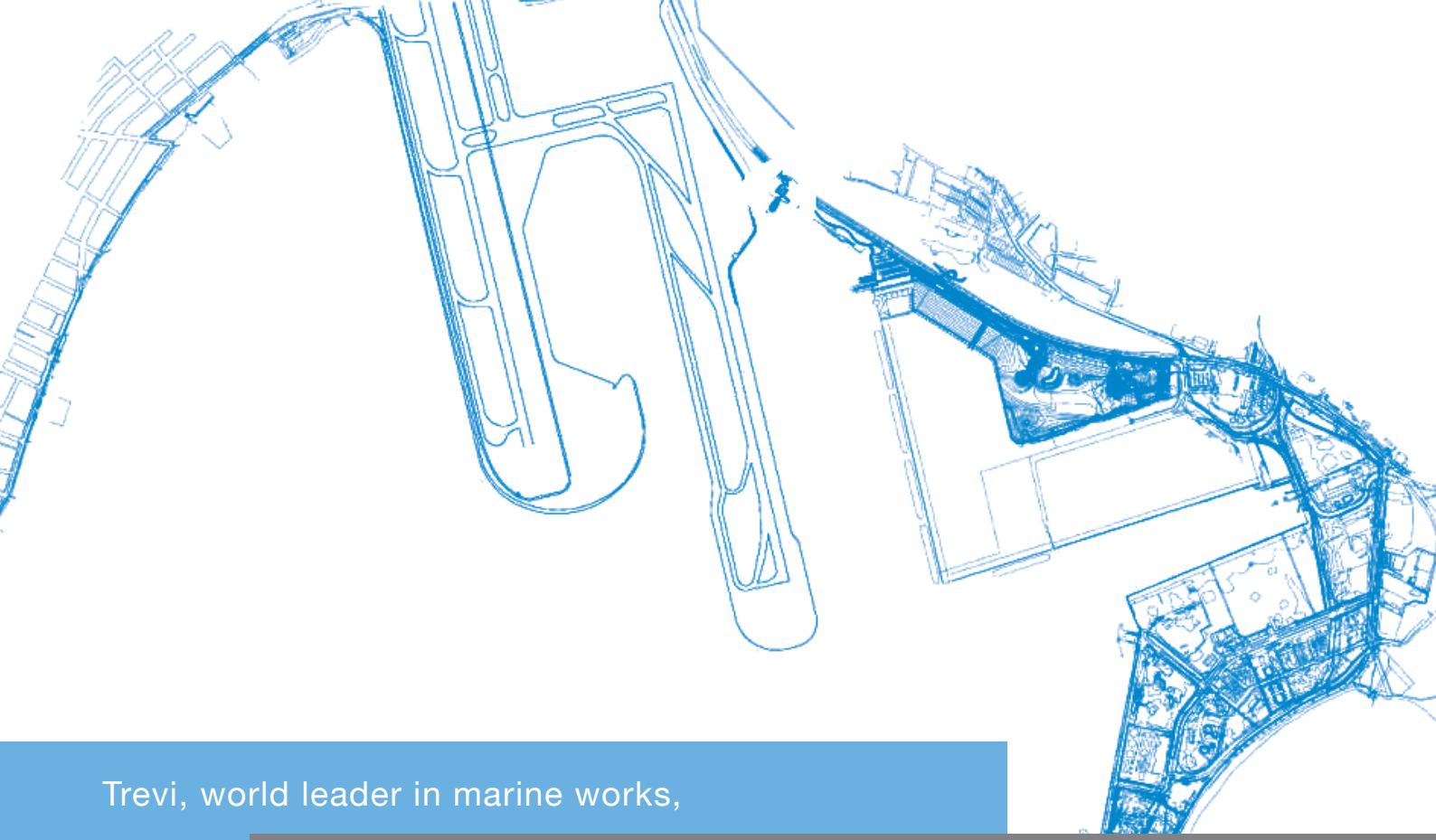


Trevi, world leader in marine works,

ports, wharves & jetties

The Group

Today, Trevi Group is worldwide acknowledged in the field of foundation engineering thanks to the field experience it has acquired, the technology it uses, the constant ability to find timely new and innovative solutions on complex civil engineering needs *(thanks to the never ceasing integration and interchange among the two divisions Trevi and Soilmec)*, and for its predisposition to integrate and collaborate with the local cultures.

The Group has been listed on the Milan Stock Exchange since 1999.

Trevi

Trevi has managed to satisfy the multifaceted requirements of foundation industry, always showing a positive approach towards cultures different from its own. In this way, Trevi has succeeded in developing innovative global technologies - thanks to practical and first-hand analyses carried out by skilled professionals and experts - as well as modern and streamlined production systems; the teams' hard work spread out across faraway lands and was held together by shared values and by a passion that knows no borders. Nowadays, Trevi is one of the major world leaders in foundation engineering. Trevi is extremely dynamic thanks to the continuous search for new solutions to the complex problems currently being tackled by civil engineering around the world.

What are TREVI's strong points?

The ability to work in different scenarios, the willingness to challenge its own knowledge by dealing with other engineering cultures, a flexible management of human resources - by means of a continuous training -, the importance given to a positive and stimulating work environment, the choice of making its branches work autonomously and take operating decisions while never ceasing to follow the guidelines defined by the mother company.

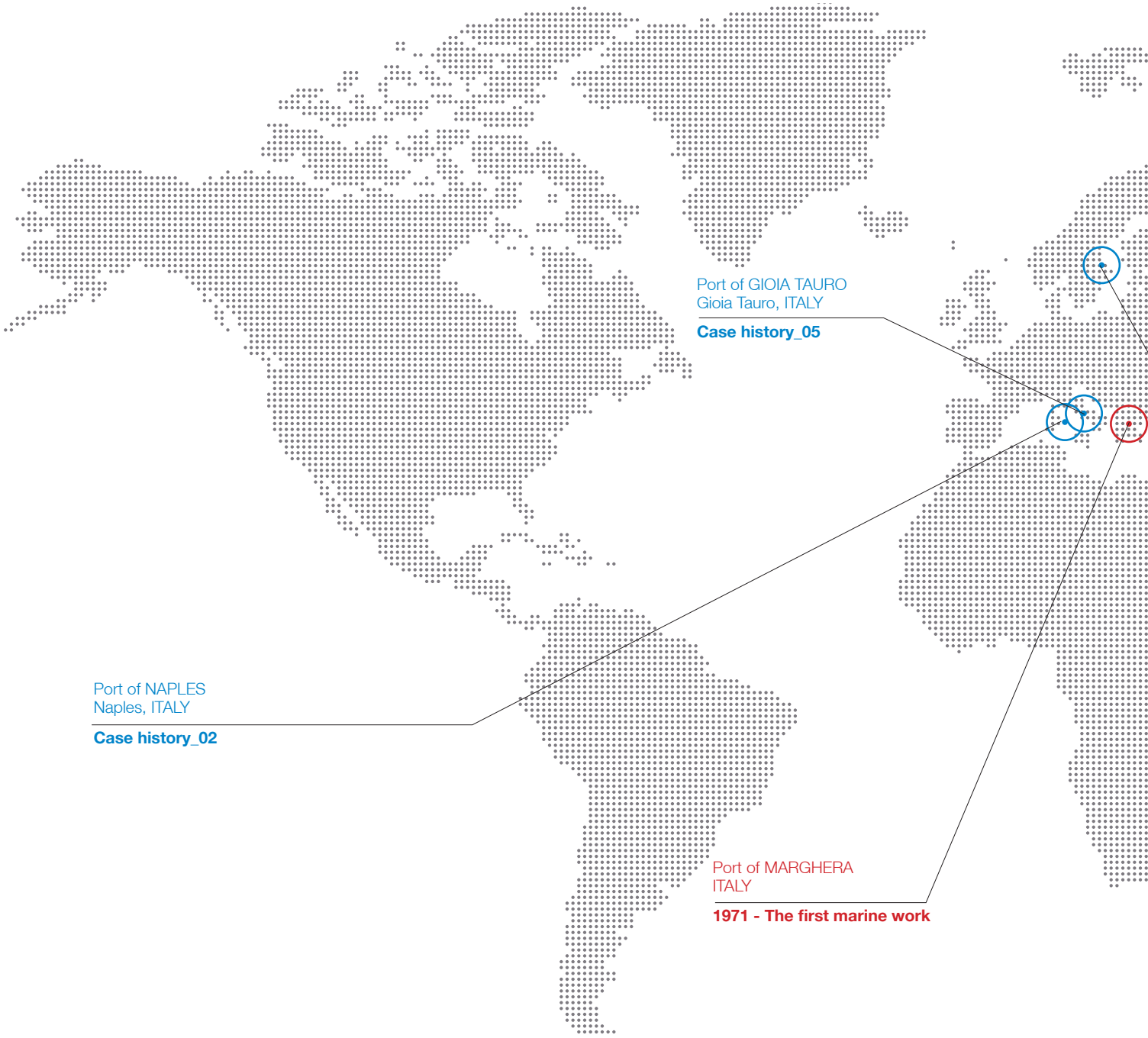
Which targets? Safety, quality, efficiency, specialization, flexibility.

Cover: **Commercial Port of Gioia Tauro, Italy**
Picture on the right: **FOT Onne, Berth 9,10 and 11 - Nigeria**

Global leader in ports, wharves & jetties

TREVI Group boasts a wide experience in the realization of important and complex marine projects and works. **More than 200 projects** have been successfully completed throughout the world, including numberless interventions, among which bored or driven piles, sheet-piles, cofferdams, complete wharves and piers, shore protection, off-shore excavations and small drainage works, coast rehabilitation works.

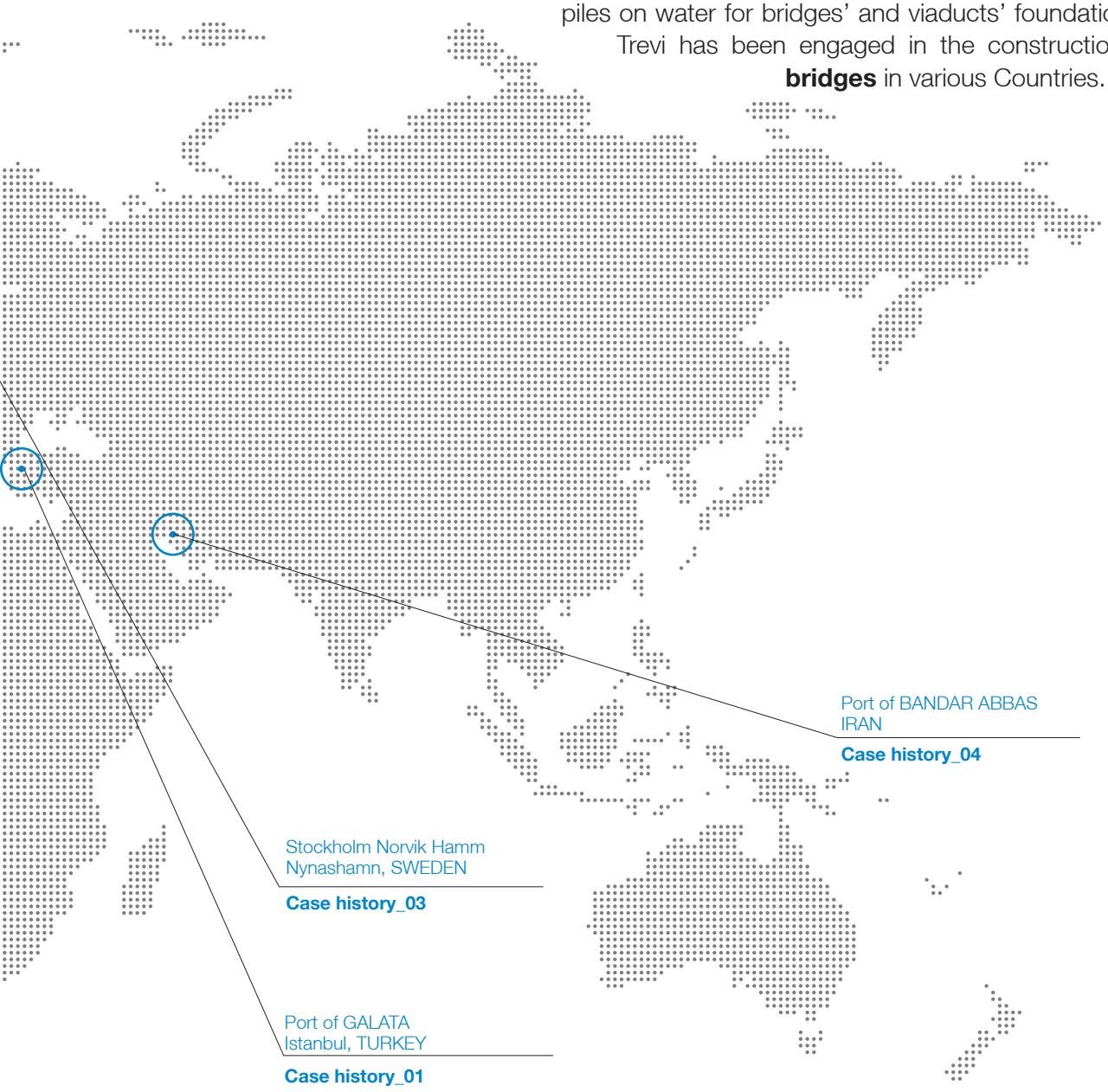
TREVI Group can provide comprehensive solutions including special foundation works and shore protection, off-shore excavations and dredging, reinforced-concrete civil



and structural works, paving, viaducts, electrical and hydraulic systems, infrastructure. Works are designed and accomplished by using state-of the-art technologies and equipment, ensuring environmental protection and complying with the requirements set by local regulations.

Foundation structures play a major role in absorbing axial and/or horizontal loads generated by superstructure (docks, piers, wharves, bridges, viaducts, etc.) and in transferring them to the soil. Foundations can also serve as temporary or permanent support structures for excavations or as underground water retention structures.

In the marine works field Trevi is capable of performing bored and driven piles on water for bridges' and viaducts' foundations. Up to now Trevi has been engaged in the construction of about **60 bridges** in various Countries.



Galataport Project
Istanbul, TURKEY

Owner:	Galataport İstanbul Liman İşletmeciliği ve Yatırımları A.Ş.
Main Contractor:	Trevi Spa
Completion Date:	2019

The Project involves the construction of a modern terminal for cruise ships *(world-first in underground boarding bridge systems for ships)*, the restoration of historical buildings and redevelopment of the port area that has been closed to public for nearly 200 years. The Port has up to 1200 m of coastline and covers an area of approximately 100000 m^2. It is located on the west coast of the Bosphorus, next to the Galata Bridge on the Golden Horn.

The Multi-Purpose Bottom Plug (MPBP)

This innovative geotechnical solution is a combination of seepage control, ground improvement against liquefaction, and load bearing elements. It was adopted to allow the deep excavation of a 3-basement building *(12.5 m depth, 11.0 m undersea).*

Seepage Control: Bottom plug formed by overlapping jet grouting circular columns *(2000 mm diameter, double-fluid),* executed on a triangular pattern with an average c/c spacing of 1500 mm.
Liquefaction risk mitigation: Pseudo-elliptical jet grouting columns on a lattice-type pattern. Average width of columns is 4.0 m.

Stability against uplift: permanent 63.5 mm Double Corrosion Protected *(DCP)* steel bars, installed as drilled *(250 mm diameter drill-hole)* and grouted micropiles through the previously-executed elliptical jet grouting columns.

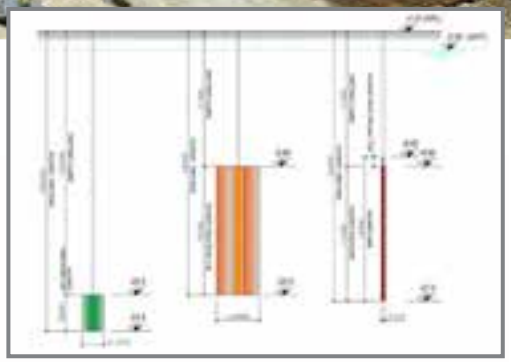
Basis of design

The bottom plug's thickness and depth were designed to ensure the hydraulic stability of the excavation. The unit cell of pseudo-elliptical jet grouting was designed through a non-linear time history 3D FDM analysis. The seismic input considered for the analysis was the Izmit-Kocaeli event of 17 August 1999. Micropiles were designed as "fully embedded in elliptical jet grouting", considering an ultimate micropile-to-jet grouting skin friction of 400 kPa.

Preliminary & Final Tests

- Length, width, strength and overlapping of elliptical jet grouting columns *(coring, laboratory tests, seismic cross hole tomography);*
- Diameter and overlapping between circular bottom plug columns *(coring, laboratory test, seismic cross hole tomography);*
- Hydraulic conductivity of bottom plug *(in-situ pumping test);*
- Tensile capacity of DCP micropile, executed inside elliptical jet grouting columns *(instrumented in-situ tensile load test).*

BIM of
MPBP basic element



MPBP: Section view of single elements

MPBP: Typical Layout

Port of Naples
Naples, ITALY

Owner:	Port Authority of Naples
Engineer:	Association composed by: **Technital - Acquatecno - Sevizi Integrati - DAM**
Main Contractor:	ATI Trevi - C.C.C.

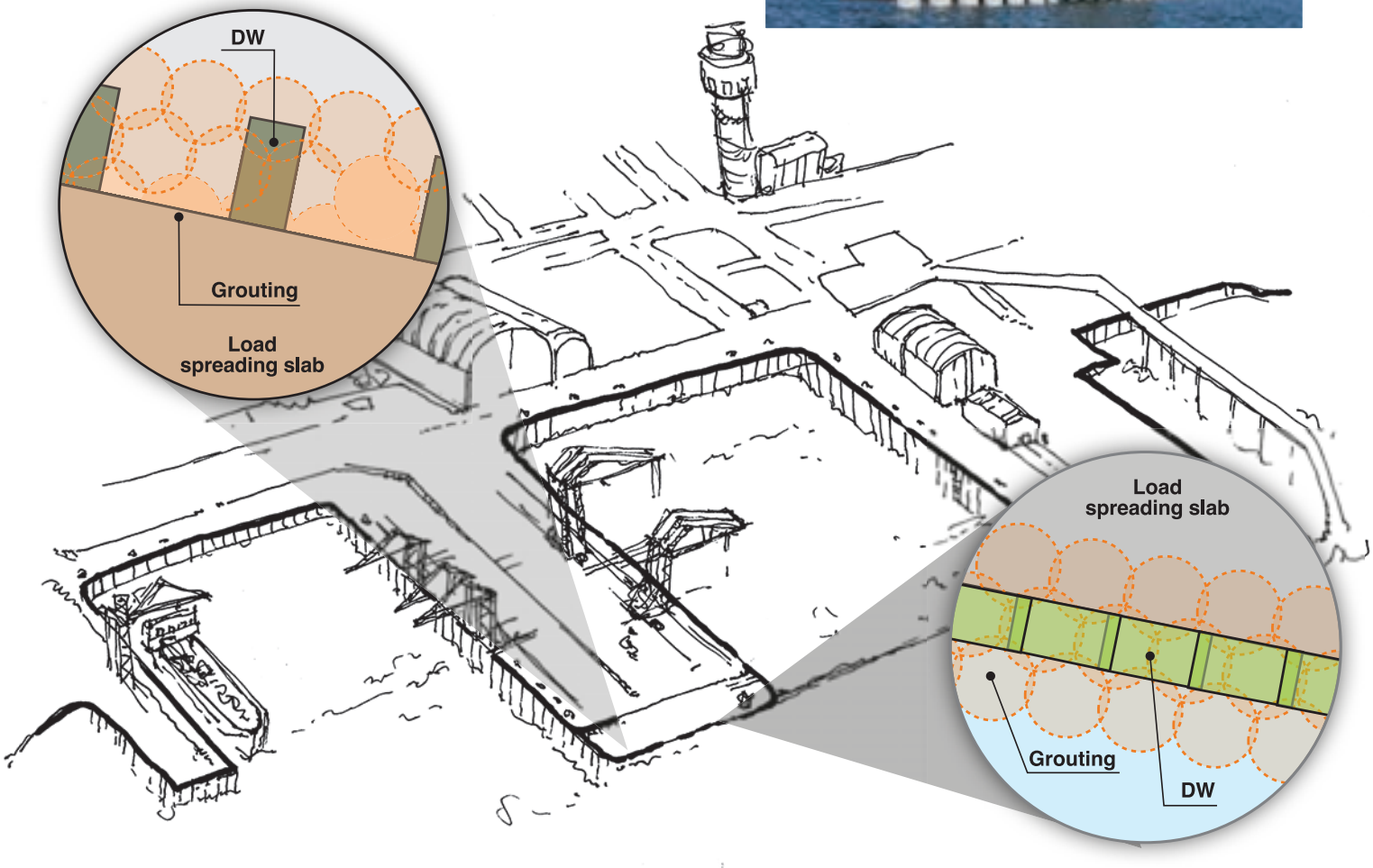
Trevi - C.C.C. joint venture is carrying out the second execution stage of the general project for the construction of a new Container Terminal and Sediment Tank in the Port of Naples, in the pre-existing eastern dock.
At present, the eastern dock has variable depth from 7 to 15 m, water surface of approximately 7 hectars. The length of the quays ranges between 250 m and 285 m.
The Terminal will be built by confining and filling the dock and the 200 m long extension of the Terminal with the sediments dredged from the bottom of the port of Naples. For this purpose, the eastern dock must be completely waterproofed to form a sort of box with permeability equal to K<10-9 m/s on all sides of the perimeter and on the base. The filling of the reclaimed land *(cofferdam)* is not covered by this contract and it is still in the planning stage.

Activities and works to be executed within the scope of the contract are:

- execution of the combined sheet pile double-wall, drivenuntil reaching the tuff formation to a depth of 20-25 m.
The main part of the supporting structure of the quay is the 630 m long sheet piling, about 18 m deep, allowing the berthing of two container vessels with size corresponding to the vast majority of the today containers;
- construction of plastic diaphragm walls suitable to confine the tank;
- construction of bored piles within the main elements of the combined double-wall, serving as foundation for the upper superstructures on the dock surface *(dock cranes, etc.);*
- construction of a new cooling water system for the circuit of the Tirreno Power Plant, including consolidation of the seabed with jet-grouting for the intake and discharge of the cooling circuit of the Tirreno Power Plant;
- consolidation of the Progress pier head with micropiles and jet grouting;
- environmental dredging of the contaminated sediments at the bottom of the dock.

The subsoil of the dock consists of the following layers' sequence: anthropogenic backfill *(fill)*; sandy-silty soils of the bottom *(upper sands)*; lithoid tufa *(tuff)*; sandy soils of the bottom *(lower sands)*.

CFA piles *(plastic diaph.wall)*:	**1.002** *(16.000 sq.m tot)*
Bored piles:	**10.500 m** *(ø 1.400 mm and 1.600 mm)*
Discrepiles:	**3.936** *(ø 900 m, 17.000 m tot)*
Micropiles:	**140** *(ø 300 mm, 3.400 m tot)*
Injections:	**280** *(3.780 m tot)*
Jet grouting:	**110** *(1.320 m tot)*


DW
Grouting
Load
spreading slab
Load
spreading slab
Grouting
DW

Stockholm Norvik Hamn
Nynashamn, Sweden

Owner:	Stockholm Hamnar / NCC
Main Contractor:	NCC AB
Completion Date:	2016 - 2017

Stockholms Hamnar (Ports of Stockholm) awarded a contract to HERCULES-TREVI Foundations AB, the Swedish branch of TREVI Group, for the preparatory works concerning construction of a new terminal container, named Norvik Port, in Nynäshamn, a town located 60 kilometers south-west of the Swedish capital. **The port of Stockholm, in fact, is located in the historic center of the city. This feature is not compatible anymore with modern transport requirements and contributes to causing traffic congestion in urban areas.** Therefore, the Swedish authorities decided to build a new commercial dock in an extra-urban area, mostly dedicated to the storage of containers.

The aforementioned area partially encompasses a zone made up of filling material, whose sediments are characterized by a variable granulometry ranging from clay to boulders, even a few meters large. In order to support the heavy loads of the port, it was necessary to consolidate the soil underneath the port yards through the installation of lime cement columns and jet grouting, while heavy dynamic compaction was used a for the crushed rock backfill's improvement.

The dynamic compaction technique has proved to be efficient and functional; hence, it turns out to be a goal-oriented method and confirms TREVI Group as a leader in the selection, proposal and application of modern and innovative technologies in any geotechnical sector.

Port of Bandar Abbas
Bandar Abbas, IRAN

Owner:	P.S.O. - Teheran Port & Shipping Organization
Main Contractor:	Italcontractor Consortium

The New Bandar Abbas Commercial Port, covers an area of approximately 20 square kilometers and is equipped with extremely sophisticated structures allowing the storage of huge quantities of goods and the quick loading and unloading of vessels.

The New Bandar Abbas Commercial Port is considered one of the most complete in the world.

Many difficulties had to be overcome in building this impressive structure.

The area devoted to goods storage includes 190,000 sq.m of covered ground and 1,500,000 sq.m of paving with an internal railway network extending over 19 km. The wharf longer than 5 km and allows the simultaneous docking of 25 large tonnage vessels.

Trevi was awarded the contract for all foundation works, including:

- T-shaped panels for the construction of docking wharves;
- linear panels for the construction of tie-rod anchorage walls;
- assembly, laying and tensioning of anchorage tie-rods;
- foundation piles for the bridge cranes on the wharves;
- foundation piles for the existing buildings in the port area;
- plastic cut-off for the slipway.

To ensure proper execution of works, it was necessary to develop and employ suitable technologies capable of solving the many problems arising from the peculiar nature of the soil and from the environmental conditions. In order to achieve this goal, Trevi relied on the experience and collaboration of its associate Soilmec, which supplied all the necessary machinery and equipment.

Cased bored piles:	**840** *(ø 800 mm & 1.200 mm, depth 35-48 m)*
CFA piles :	**200** *(ø 800 mm)*
CFA piles:	**3.400** *(ø 500 mm)*
RD precast:	**2.466**
Tie-rods:	**310** *(36 m)*

Port of Gioia Tauro
Gioia Tauro, ITALY

Owner:	Cassa del Mezzogiorno - Rome Port Authority Gioia Tauro
Construction Manager:	COGITAN Consortium

The port of Gioia Tauro, built in the Seventies in anticipation of the creation of an important steel working centre, was almost totally abandoned when the sector was hit by recession.
After more than 20 years, the growth of container shipping offered a new lease of life to the port: it seized this opportunity by completing work on the wharfs along the north basin and constructing a new quay.

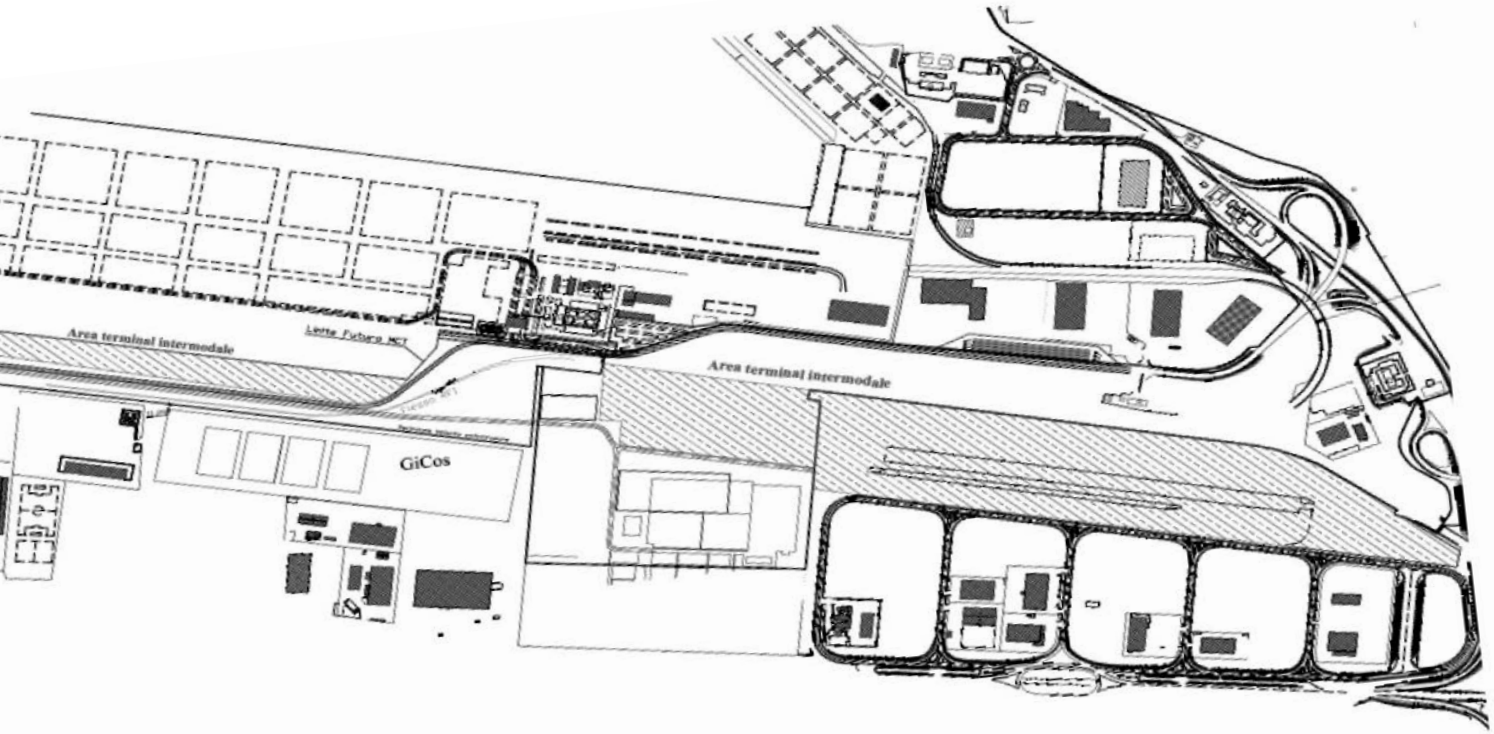
In addition to these works, all the civil engineering paving works were carried out, underground utilities were created and new bollards, crane rails and railway lines installed.
In detail, the project involved important consolidation work of all the load-bearing structures (caissons, pillars, spandrel beams), new shoring works and connecting works to the existing works, the creation of a surface drainage system, protective measures against marine erosion and consolidation of filled ground.

The wharf foundation works involved:

- consolidating and protecting the sloping ground between the piles using jet grouting;
- installing a continuous connecting slab between the main beams on the sea and shore sides;
- constructing a continuous drainage system.

The seabed was built back up by dumping small-sized material and was properly levelled out with the help of divers; new beams connecting the piles were installed; a new anti-reflecting structure was built using secant piles; a continuous connecting slab between the piles and the internal diaphragm shoring walls was constructed.

Diaphragm wall (T-shaped):	220.000 sq.m
Bored piles (for wharf) :	110.000 m


Area terminal intermodale
Area terminal intermodale
GiCos

Market trends and the technical approach to solutions

Global economic growth is closely linked to the possibility of transporting large quantities of goods in a shorter space of time and with lower costs. Of all the different means of **transporting cargo, shipment by sea is by far the most widely used and the cheapest;** over the past few years this has led to a considerable increase in maritime traffic.
Increased traffic and falling costs have been countered by the construction of larger and larger container ships. And as the size of the ships grows, so does the need to build wharfs deep enough to accommodate bigger and bigger drafts.

The speed with which container ships are loaded and unloaded is also on the increase and this, in turn, calls for **larger and larger equipment.**

All these changes have give rise to a demand in new building work:

- new wharfs in ports large enough to accommodate greater depths and large loads concentrated on the surface;
- reconditioning of existing wharfs which have fallen into disuse and disrepair, including dredging seabeds to make them deep enough to receive larger ships;
- building of jetties for loading mining or oil and gas ships.

As regards ships for the oil and gas industry, special jetties are built which can sometimes be several miles long to discharge raw materials through pipelines.


Anversa Port


Hong Kong Port


Aerial container terminal

Trevi Group solutions

Its long-standing experience in special engineering works has made Trevi a benchmark in the port infrastructure construction business.

The main technologies it uses are:

- **reinforced concrete diaphragm walls or steel sheet piles** to support the soil or act as anchorage;
- **driven or reinforced concrete piles** to support vertical loads;
- **tiebacks in steel bars** or strands to support waterfront works;
- **augered or driven piles, deep mixing or jet grouting, dynamic compaction** for soil consolidation.

Work to modernise or build new docking facilities in ports often generates substantial sediment flow. If this sediment is contaminated, it must be properly treated. Dredged sediment can either be reused as such, if suitable, or must be disposed of in dedicated facilities located at the port itself or in landfills.

Over the past few years, Trevi has developed technological solutions to manage the entire dredged sediment process.

In particular the company has developed technologies concerning:

- **low impact selective dredging;**
- **grain size separation** of sediment and differentiated treatment of the fractions;
- **detoxification of the fraction contaminated** by organic compounds *(in collaboration with 3V Green Eagle of Bergamo);*
- **consolidation of sediment** during transportation to the containment facilities.

This multidisciplinary approach offers outstanding technical and financial benefits:

a) produces reusable material;

b) process is flexible;

c) can be integrated with tried and tested processes;

d) reduces contamination *(reduced running costs)***;**

e) reduces time needed to deliver the usable areas.


Rehabilitation of Messina harbour


Obra Mega y Profertil_ Bahía Blanca, B.A_Argentina


Sheik Khalifa Bin Salman Causeway_ Ba<hrain


Mar Grande,new wharves, Taranto_Italy

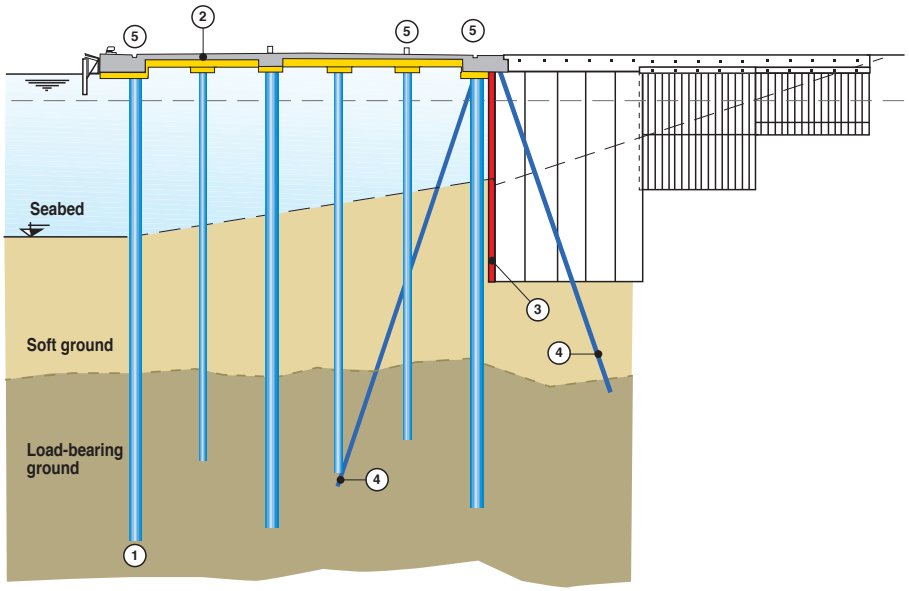

Q. Chem Petrolchemical Complex_Qatar

Our service

Open-type wharfs

Concrete piles support a reinforced concrete deck; a rear reinforced concrete diaphragm wall separates the land from the water; thrust is partly countered by raked steel driven piles. The works can be executed partly from the water. The structure is able to support crane rails on the first and last deck on piles.

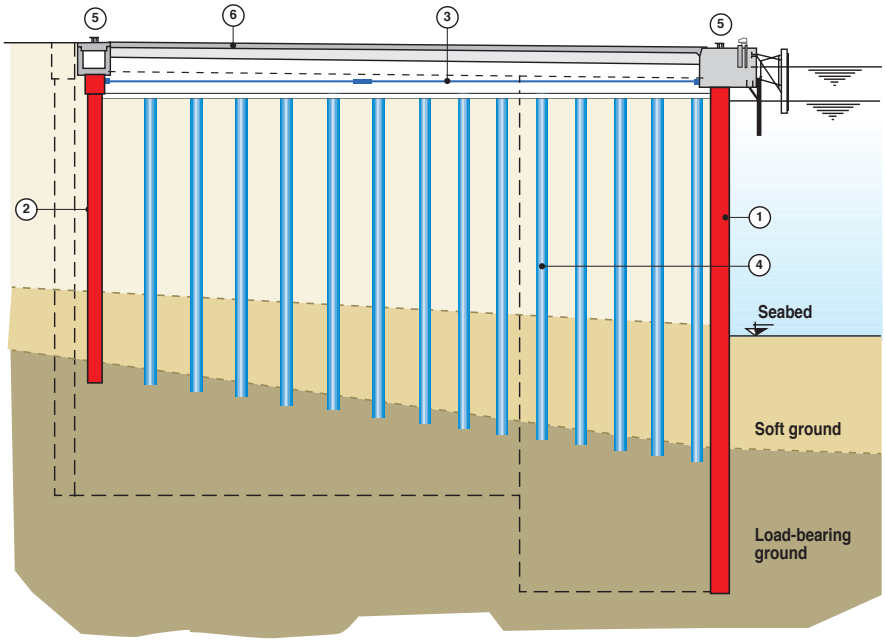
1_Concrete / steel piles
2_Reinforced concrete or steel deck
3_Reinforced concrete diaphragm walls
4_Raked steel driven piles
5_Crane rails

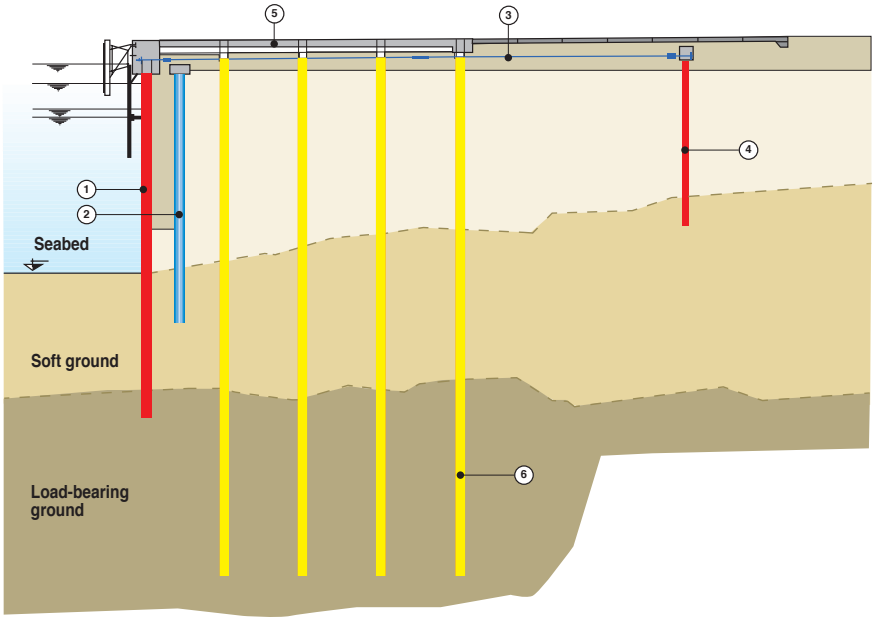


Closed-type wharfs

A reinforced concrete diaphragm wall separates the land from the water; a second rear diaphragm wall provides anchorage for the supporting tiebacks; the soil is consolidated in situ using concrete vibrated piles or other technologies. The structures in this type of wharf can also support self-propelled cranes over the whole paving or rails for gantry cranes.

1_Front diaphragm wall
2_Rear diaphragm wall
3_Tiebacks
4_Consolidated soil
5_Crane rails
6_Paving

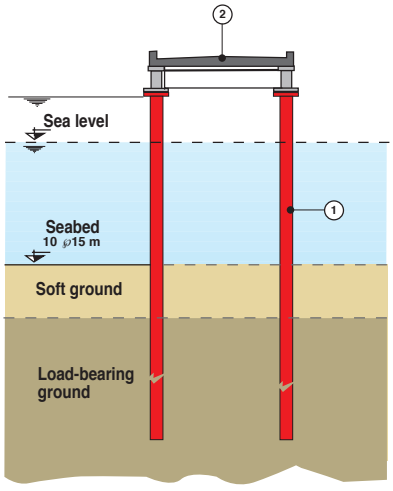




Renovation of existing wharfs

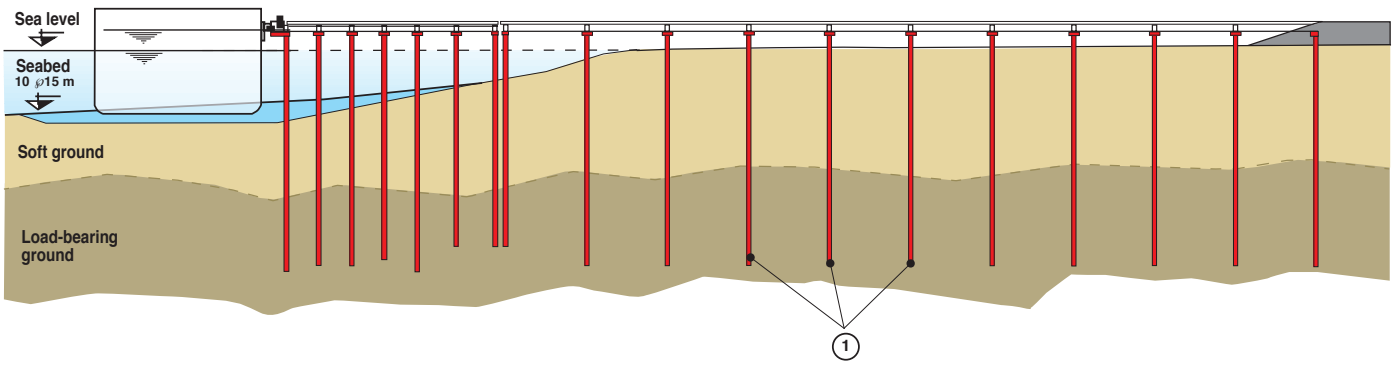
An old wharf is renovated by constructing a new supporting deck in front of the old front wall; the new deck is held up by a tieback connected to rear sheet piling; a new slab on pre-cast driven piles supports the greater loads expected and prevents increased thrust on the front sheet piling.

1_New front diaphragm wall
2_Existing diaphragm wall
3_Tiebacks
4_New rear diaphragm wall
5_Support piles
6_Slab



Jetties

Jetties can be constructed from the shore, using the structures just built to advance or from the sea using pontoons. Steel driven piles or vibrated piles with sheet steel may be used and filled with reinforced concrete; the deck can be in partially pre-cast reinforced concrete (typically for permanent structures) or in steel with or without a covering slab in reinforced concrete (typically for temporary structures).



Ports: sustainable management of dredged sediment

The key objective of sustainable dredged sediment management is to **recover as much sediment as possible** which can then be reused in port and harbour activities or on land.
Even when the sediment is conveyed to confined facilities or reused for filling, it must be given the appropriate **chemical, physical and geomechanical characteristics.**

Trevi Group has developed and applied innovative sediment management technologies which can be customised upon specific request. These processes (see diagram 1) cover the entire sediment management process, with the objective of recovering as much of the resource as possible.

Applying the "zero discharge" approach, the aim of the processes is to recover even the fine fractions which are usually disposed of as waste.

There are two options, briefly described below.

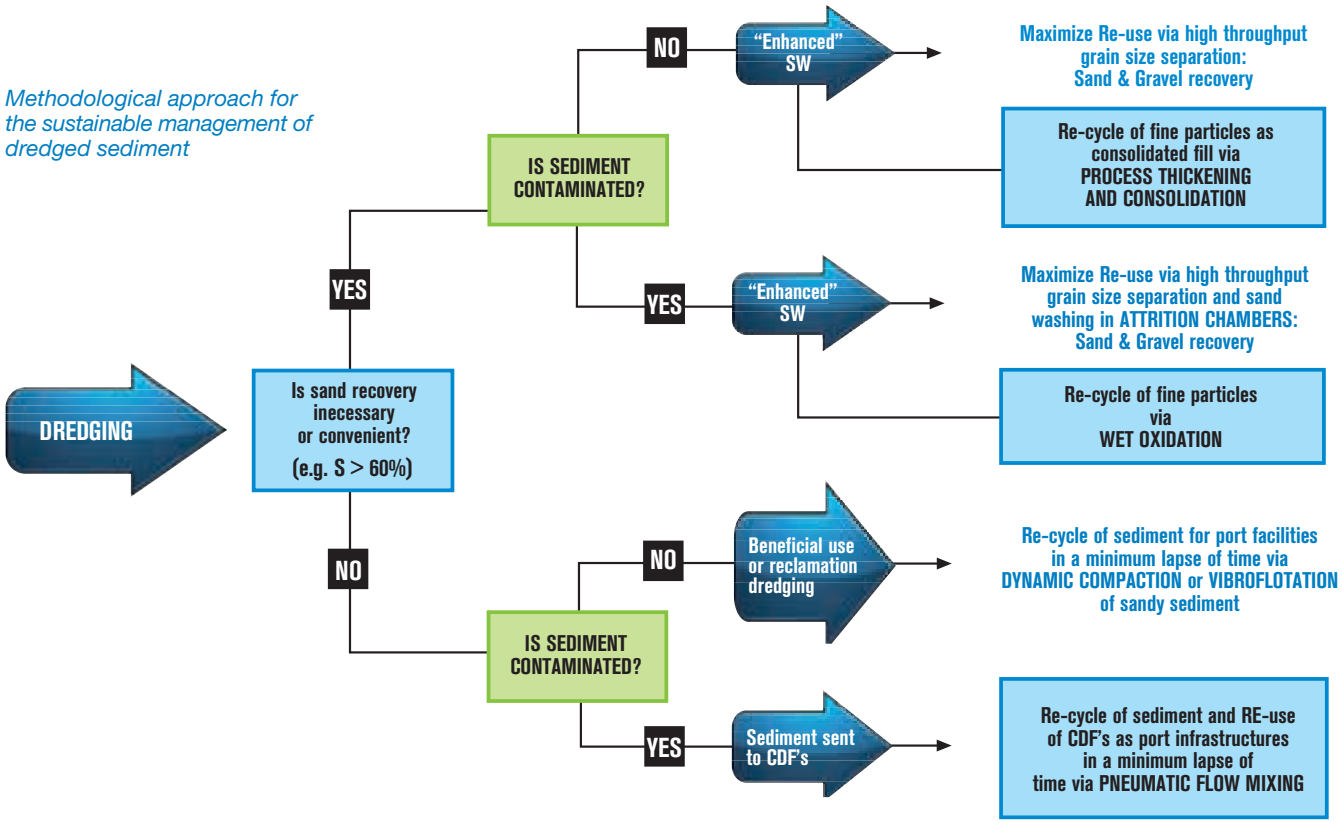
Process 1:

recovery of the sandy fraction and, if appropriate and upon consolidation, the silty fraction

The **sediment washing (SW)** process is implemented to recover the sandy fraction (worthwhile if the percentage is high) and involves grain size separation (gravel, sand, fines), reducing the possibility of contamination of the sandy fraction and, at the same time, thickening the fine fraction.
The **process patented** by Trevi involves mixing the fine fraction with binders during thickening in centrifuge ***("process" consolidation)*** in order to obtain a material with the right characteristics in the shortest time possible.

In the event of highly contaminated incoming sediment, the silty-clayey separated fraction further concentrates contamination. A technologically advanced process

Methodological approach for the sustainable management of dredged sediment



called **wet oxidation** can be used to decontaminate this fraction and involves detoxifying the fine fraction and recovering the treated solid which can then be utilised as building material.

Process 2:

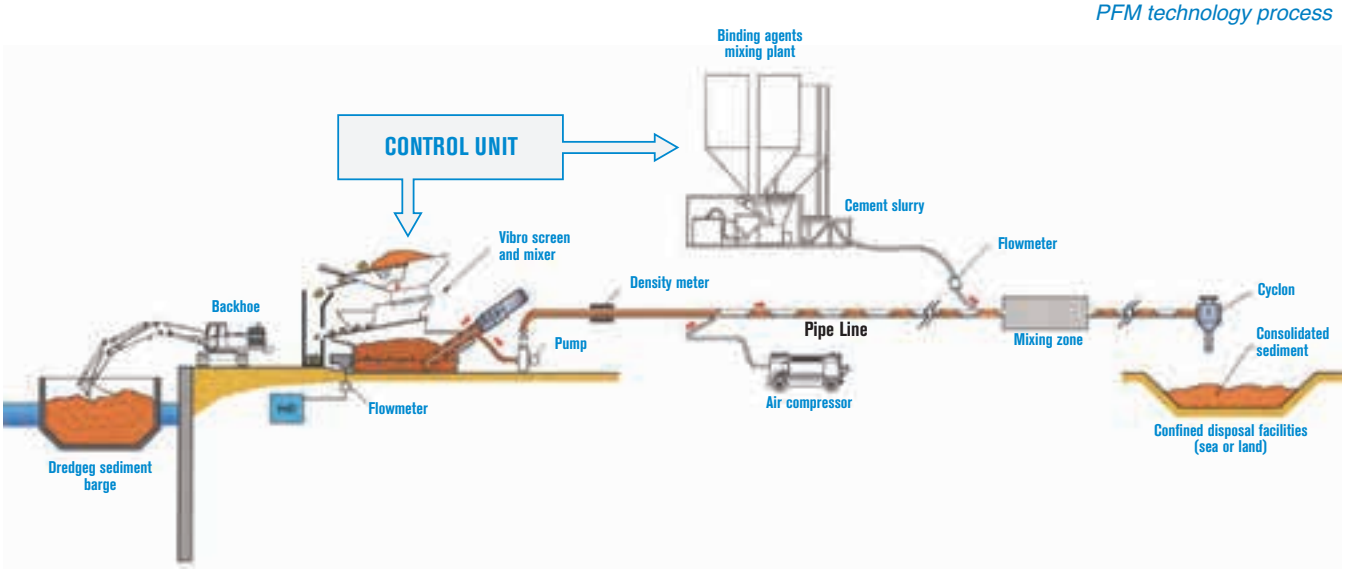
reuse of sediment as such, as building material

Even sediment that is predominantly fine can be reused as building material, as long as it is appropriately "consolidated" and, if it is contaminated, correctly disposed of. One of the technologies offered by Trevi to deal with this problem is **pneumatic flow mixing (PFM).**

This **single process** manages all the different stages of the process ***(transportation, consolidation and disposal)*** with considerable savings in costs and time.

This technology is highly recommended when handling large volumes.

PFM technology process



Industrial plants and pilot plants

The above-mentioned plants and processes have been widely tested in different conditions and with a variety of materials *(sediment from the ports of Marghera, La Spezia, Livorno, Palermo, Naples)*. The tests have shown the effectiveness of the technologies and the modularity/elasticity of the entire process.

Trevi can supply standard mobile industrial plants with a productivity rate of 50 m^3/h for SW treatment and 150 m^3/h for PFM *(incoming material)*.

Customised plants can be supplied upon special request.

Pilot plants for all the technologies described are available for designers and technicians. They replicate the production process on a small scale *(a couple of m^3)* to enable them to rapidly assess the economic feasibility of the solution according to the site-specific characteristics of the sediment.

www.trevispa.com