Piles

Processes

Techniques
and applications

Build on us

SOLETANCHE BACHY

From a small basement situated in challenging ground conditions to a complex foundation scheme to support an iconic structure, any deep-foundation project requires in-depth analysis and experience in order to select and then implement the right solution.

At Soletanche Bachy, our highly committed teams excel in a diverse range of foundation techniques, and are experienced in all sectors of their application, ensuring that the best choice is always tailored specifically to the client's project.

Thanks to our large fleet of rigs worldwide and our capability to design and manufacture proprietary equipment, our highly skilled teams are constantly striving to improve traditional piling techniques whilst developing new innovative methods.

With this brochure, we wish to share our commitment to deep-foundation projects and highlight unique added benefits that only we can offer to our clients.

Atlantic Bridge | Panama
RODIO KRONSA + RODIO-SWISSBORING PANAMÁ

The Atlantic Bridge is located 3km north of the Gatun Locks at the mouth of the Panama Canal. With a central span of 530m, it is one of the longest concrete cable-stayed bridges in the world. Soletanche Bachy subsidiaries Rodio Kronsa (Spain) and Rodio-Swissboring Panamá installed 673 bored piles with diameters from 700 to 2,500mm for the new bridge. The LDA piles were drilled under bentonite mud using BG36 and SR70 rigs to depths of 52m. The piles were reinforced over their full depth, and tremie concreted with a specially formulated mix to provide a foundation with a design life of 100 years.

Contents

6 Build on us

6 A full suite of piling solutions

8 At the cutting edge

8 Pride in our fleet

9 The safe way is the only way

10 Large diameter bored piles

13 Under-ream piles

13 Base-grouted piles

13 SolThread

14 Barrettes

15 Plunge columns

16 Large diameter rock drilling

16 Traditional rotary techniques

17 Down The Hole hammer drilling

17 Casing advancement systems

18 Cluster drills

19 Reverse Circulation Drilling

22 Continuous flight auger piles (CFA)

24 Starsol®

25 T-Piles®

26 Rotary displacement piles

28 Threaded Screw Piles (Screwsol)

29 Continuous Helicoidal Displacement piles

29 DSP_{STAR} and TSP_{STAR}

30 Driven piles

31 Driven pre-manufactured piles

32 Driven cast in-situ piles

36 Constrained access & low-headroom works

36 Micro and minipiles

38 Low-headroom large diameter bored piles

41 Low-headroom barrettes

42 Embedded bored pile retaining walls

44 Secant pile walls

47 Contiguous bored pile walls

47 Discontinuous bored pile walls

48 Summary of techniques

Build on us

Key figures

10,265 employees

4,600 projects a year

50 countries of location

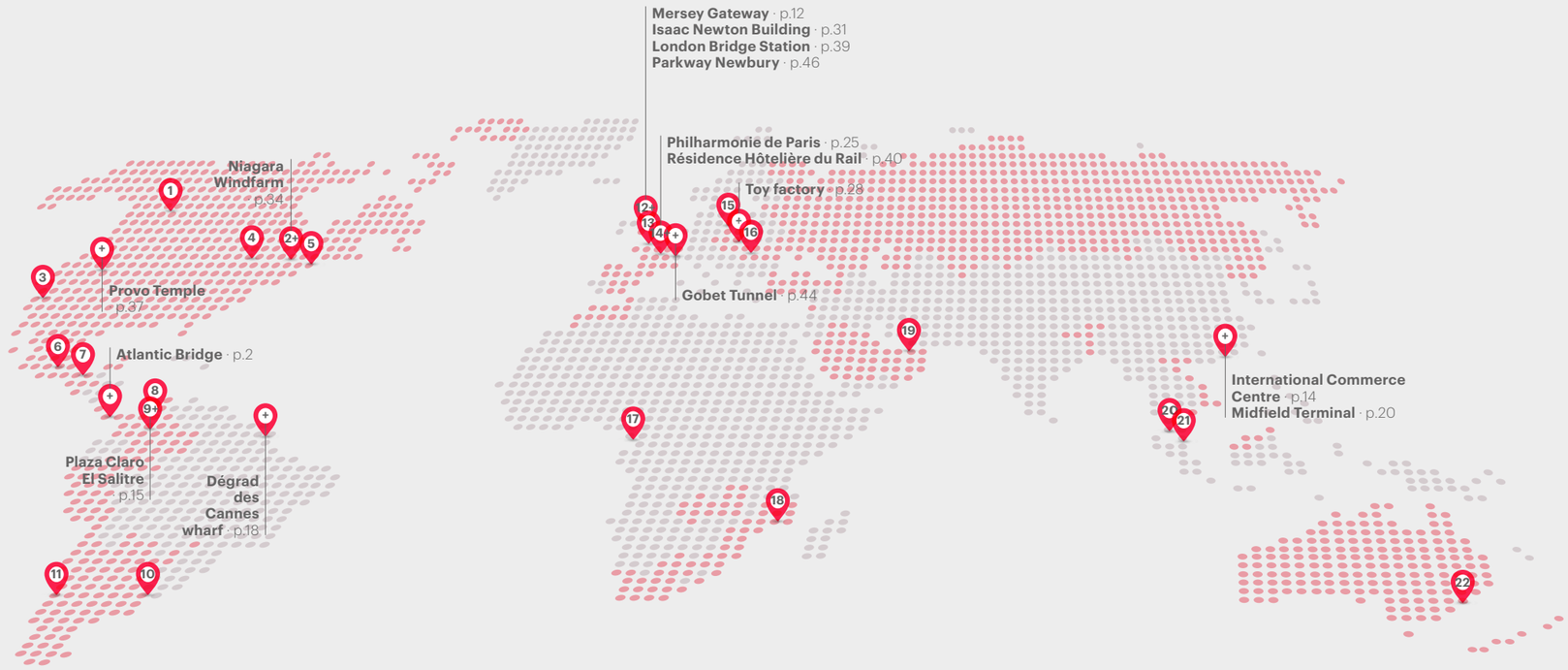
70 countries of operation

1.5 billion euro revenue

The Soletanche Bachy Group is one of the world's largest geotechnical contractors. It offers a unique and diverse range of solutions including deep foundations, retaining walls, cut-offs, ground stabilisation and remediation, instrumentation and monitoring, and grouting. All around the globe, Soletanche Bachy serves clients in the public and private sectors and delivers a comprehensive range of services and processes. Equally motivated by niche specialist projects and large infrastructure developments, Soletanche Bachy is capable of undertaking contracts as a specialist subcontractor, a joint venture partner or a main contractor.

A full suite of piling solutions

For almost a century, the Group has provided a full suite of piling solutions. Among the techniques and applications: large diameter bored piles and barrettes for mega-structures, screw displacement piling for contaminated land projects, minipiling and low-headroom solutions for underpinning and basement works, large diameter RCD and other miscellaneous techniques for drilling hard rock, driven precast concrete piles for industrial developments, and driven steel piles for offshore works and quayside combi-walls. Committed to excellence and innovation, the Group is constantly striving to improve traditional techniques whilst developing new methods.



Read on for further details.

Diverse and flexible

	Technique	No.	Dia. in mm	Depth in m
1	**Scotford HCU Debottleneck** | Alberta, Canada			
	CFA	391	500 & 600	up to 20
	AGRA FOUNDATIONS			
2	**P&H Hamilton Flour Mill** | Ontario, Canada			
	Driven steel piles	1,140	244	30.5
	BERMINGHAM			
3	**Transbay Bus Ramp** | San Francisco, USA			
	Barrettes	2	6.4×1.5	55
	NICHOLSON CONSTRUCTION			
4	**Bridge on I-90** | Cleveland, USA			
	LDA	16	1,800	55
	NICHOLSON CONSTRUCTION			
5	**World Trade Center** | USA			
	Micropiles	459	273	45
	NICHOLSON CONSTRUCTION			

	Technique	No.	Dia. in mm	Depth in m
6	**Diana Tower** | Mexico			
	LDA	49	up to 2,600	54
	CIMESA			
7	**Etileno XXI** | Mexico			
	Starsol®	720	620 & 820	12
	CIMESA			
8	**Yatí-Bodega Bridge** | Colombia			
	LDA + permanent casing			
	Offshore bearing piles	40	1,500 & 2,000	up to 69.5
	Onshore bearing piles	280	1,500 & 2,000	up to 58
	GEOFUNDACIONES			
9	**Gran Plaza San Mateo Mall** | Soacha, Colombia			
	Press-in driven concrete piles	1,652	3,500 ×3,500 & 4,000 ×4,000	up to 41
	SOLETANCHE BACHY CIMAS			

	Technique	No.	Dia. in mm	Depth in m
10	**Guillermo Brown jetty, Bahía Blanca** | Argentina			
	LDA		1,000, 1,300 & 1,600	up to 35
	Offshore bearing piles	156		
	SOLETANCHE BACHY INTERNATIONAL + SOLETANCHE BACHY ARGENTINA			
11	**Mall Center** | Concepción, Chile			
	LDA	155	1,000 & 1,500	up to 30
	SOLETANCHE BACHY CHILE			
12	**Wood Wharf** | London, United Kingdom			
	LDA	180	900 & 1,500	35
	CFA	500	750 & 900	27
	LDA *Secant pile walls*	280	880	20.5
	BACHY SOLETANCHE			

	Technique	No.	Dia. in mm	Depth in m
13	**Rollet Quay** | Rouen, France			
	Micropiles *Retaining and bearing piles*	148	127 & 139	30
	SOLETANCHE BACHY FRANCE			
14	**Law Court** | Paris, France			
	Starsol®	348	820, 920, 1,020 & 1,220	23
	Barrettes	78	2.8×1	49
	SOLETANCHE BACHY FRANCE			
15	**Lotos Oil Refinery** | Gdańsk, Poland			
	CFA	2,500	400, 600 & 800	24.5
	SOLETANCHE POLSKA			
16	**Ion Oblemenco Stadium** | Craiova, Romania			
	CFA	1,289	800, 900 & 1,200	up to 13.5m
	SBR SOLETANCHE BACHY FUNDAȚII			

	Technique	No.	Dia. in mm	Depth in m
17	**Wouri Bridge** | Cameroon			
	LDA + permanent casing *Offshore bearing piles*	50	2,500	70
	Driven piles *Onshore bearing piles*	40	1,500	45
	SOLETANCHE BACHY INTERNATIONAL			
18	**Moma Sands** | Mozambique			
	Driven steel piles	95	610	36
	DURA SOLETANCHE BACHY			
19	**Entisar Tower** | Dubai, UAE			
	Barrettes	139	2,800 ×1,500	80
	SOLETANCHE BACHY DUBAI BRANCH			

	Technique	No.	Dia. in mm	Depth in m
20	**Ikea & MyTown** | Kuala Lumpur, Malaysia			
	LDA + DTH hammer *Secant, contiguous and bearing piles*	2,100	570	20
	Micropiles	1,460	up to 300	up to 30
	BACHY SOLETANCHE GROUP CONSTRUCTION MALAYSIA			
21	**Amber Skye** | Singapore			
	LDA	131	from 800 to 1,300	up to 72
	LDA *Secant pile walls*	424	800, 1,000 & 1,300	from 16
	FOUNDATION ALLIANCE			
22	**Pacific Highway** | Queensland-New South Wales, Australia			
	LDA	144	900, 1,050, 1,200 & 1,350	up to 20
	AFS BACHY SOLETANCHE			

The Group's motto "Build on us" encapsulates the fundamental principles of our company; the safety of our workforce, technical expertise and innovation, reliability of plant and equipment, and the integrity of the structures that we deliver. This is the Soletanche Bachy long-term vision of sustainable growth.

At the cutting edge

Soletanche Bachy takes inspiration from its founders and prides itself in continuous investment to keep techniques and processes, and plant and equipment, at the cutting edge. Innovation is driven by an ambitious R&D policy, and Soletanche Bachy has been recognised through a number of highly acclaimed awards that reflect some of the most significant contributions ever made to drive our industry forward.

Innovation and technical expertise underpin the piling projects entrusted to Soletanche Bachy by its clients. Through local design offices and specialist Group designers alike, Soletanche Bachy is capable of providing innovative and efficient solutions. Our competence and experience are invaluable as they also promote safer sites, where works can be designed and sequenced to mitigate risk before construction activities even commence.

Through a unique network of technical experts, designers and specialist plant manufacturers, Soletanche Bachy strives to continually broaden and develop its existing portfolio of piling methods.

Pride in our fleet

The Soletanche Bachy fleet is modern and diverse, and the plant department also manufactures a broad range of plant, equipment and tools. Supported by technical and logistic teams, the Group can provide plant and equipment when and where it is needed, all over the world.

The Group's relentless approach to improving and influencing safety has also led our major external plant suppliers to follow suit by considering the operational risks associated with their equipment more critically, and further developing safety features of their own.

36
Plant yards and fabrication and maintenance facilities

500
Main piling rigs

Principal awards

2016

The Royal Society for the Prevention of Accidents
Health and Safety Awards
› **Gold Award**
The British Safety Council International Safety Awards
› **Construction & Property Services Award**
BACHY SOLETANCHE (UK)

2015

The Royal Society for the Prevention of Accidents
Health and Safety Awards
› **Gold Award**
BACHY SOLETANCHE + ROGER BULLIVANT (UK)

Ground Engineering Awards
› **Health and Safety Award**
› **UK Project with a Geotechnical Value of between £1M and £3M**
› **UK Project with a Geotechnical Value of between £500K and £1M**
BACHY SOLETANCHE + SOIL ENGINEERING (UK)

2014

The Royal Society for the Prevention of Accidents
Health and Safety Awards
› **Silver Award**
BACHY SOLETANCHE SINGAPORE

2011

Land Transport Authority
Annual Safety Awards
› **Accident Free Million Man-Hour's Award**
BACHY SOLETANCHE SINGAPORE

2010

Sociedad Colombiana de Ingenieros
National Engineering Awards
› **Honourable Mention**
SOLETANCHE BACHY CIMAS (COLOMBIA)

Vietnam Economic Times
› **Golden Dragon Award**
BACHY SOLETANCHE VIETNAM

2005

Fédération Nationale des Travaux Publics
Innovation Awards
› **T-Pile®**
SOLETANCHE BACHY GROUP

Plant yard and fabrication and maintenance facility | France

The safe way is the only way

Health and Safety is Soletanche Bachy's primary value, and is the precondition of all other aspects of performance. The Group watchword "The safe way is the only way" emphasises our goal to strive for continuous improvement through the prevention and control of our major risks.

Training our people is an essential Health and Safety investment. Every year, dedicated and tailored training is delivered to make our projects safer and more efficient for employees and clients alike. As well as increasing workforce awareness and ownership of Health and Safety, this approach to training also broadens competences and expertise across the company.

These efforts have led to significant improvements and achievements. By striving for zero accidents, some of our major projects have already exceeded >1,000,000 man-hours worked without a lost time accident.

Large diameter bored piles

Ø DIAMETER
From 600mm to 3,600mm

I DEPTH
From 10m to >100m

Large diameter bored (also known as LDA, Kelly or drilled shaft) piles are the most traditional and still the most ubiquitous piles worldwide. They are suitable for carrying very high loads and coping with extremely challenging ground conditions. They are typically used as foundation support for large structures, but can also be adopted into piled walls for ground retention or basement construction.

Advantages of the technique

High-bearing capacity
Deep piles can be constructed with full length reinforcement to carry high loads and bending moments.

Flexible technique
It can be either onshore or offshore. Interchangeable tools to suit all ground conditions. Supplementary techniques available to improve performance of standard LDA pile.

VALUE ADDED BY SOLETANCHE BACHY

- Instrumented rigs to record drilling parameters and pile verticality.
- Ability to analyse rig instrumentation to optimise design parameters and ascertain ground characteristics.
- Design and manufacture of special suctionless tools.
- A modern, versatile fleet of more than 180 LDA piling rigs, 50 leads for crane, 280 crawler cranes and cable excavators.
- A dedicated laboratory for support mud and concrete mix design.

The LDA technique requires powerful hydraulic piling rigs. They can be used with interchangeable attachments such as augers, buckets or core barrels. Piling tools can cope with all types of granular and cohesive soils, and with rock up to a strength of 100MPa. Typically augers are used in cohesive and dry non cohesive ground, digging buckets in saturated granular strata, and a combination of rock augers and core barrels in harder strata.

The LDA piles utilise a temporary steel casing to support unstable strata and provide safe working conditions at the top of the pile bore. They can either be single-walled casings that can be vibrated or twisted into the ground, or double-walled segmental casings equipped with a cutting shoe that can be installed via the rotary drive on the rig or by an oscillator or rotator unit. The heavy-duty casings are utilised to screw casings at high torque through obstructions, hard strata or in a secant wall application. The temporary casings are extracted immediately after concreting and re-utilised.

Support fluids such as bentonite or polymer may be a more efficient way of stabilising a pile bore when compared to long temporary casings. The general principle is to maintain a positive hydrostatic head of fluid in the bore above the groundwater levels. Twin-flight mud augers and flat-sided buckets have been developed by Soletanche Bachy to optimise excavation rates in wet bores. After excavation, desanding of the drilling mud, and installation of the reinforcement, the pile is concreted. Full length tremie tubes are utilised, and a rigourous concreting process observed.

Typical construction sequence (pile bored under drilling fluid)

1. The rig is set up in the piling position and the temporary casing installation commences.

2. The casing is inserted incrementally until stable ground is reached or drilling mud is added.

3. Once casing has been installed, drilling continues until the water pressure in the ground requires the use of drilling mud.

4. The bore is completed under drilling mud to final depth. The base of the pile bore is cleaned and the mud is treated or replaced.

5. The steel reinforcement cage is inserted. The pile is concreted using a full length tremie tube.

6. The tremie tube is extracted incrementally during concreting ensuring that a minimum embedment is maintained at all times.

7. The temporary casing is removed.

Reference

Mersey Gateway | United Kingdom
BACHY SOLETANCHE

Bachy Soletanche, the Group's subsidiary in the United Kingdom, installed 158 bored piles with a diameter of 1,500mm for the main bridge approach viaducts. These piles were up to 55m deep with working loads up to 15MN. In addition, 292 bored piles with a diameter of 1,050mm provide foundations for the new elevated road system that connects to the bridge. These piles were up to 35m deep with working loads up to 8MN. All piles were drilled under bentonite support fluid, with the piles for the bridge approach viaducts being installed extremely close to the River Mersey. Rigourous concreting procedures and drilling slurry controls were required, with support and guidance being provided throughout by the Soletanche Bachy laboratory.

Under-ream piles

Under-ream, or "bell", piles are perfectly suited to providing exceedingly high-bearing capacities in stable cohesive strata. Under-reaming of piles to produce enlarged bases has traditionally been used to enhance end-bearing capacity and provide economical support for structural mega-columns. The Group manufactures its own top-hinged tools that are operated mechanically during excavation. They can produce piles with shafts up to 2.4m and enlarged bases up to 7.2m (3 times the shaft diameter).

Added advantage

High-bearing capacity
Or reduced material quantity when compared to a straight shafted pile.

Base-grouted piles

The ultimate capacity and settlement characteristics of an LDA pile can be enhanced by grouting the base or shaft after it has been constructed. Steel tubes connected to *Tubes-À-Manchettes* (TAMs) can be incorporated into the reinforcement cages prior to concreting. Cement grout is injected at high pressure through the TAMs and forced into the ground to consolidate the soil's characteristics. By flushing out each circuit, the operation can be repeated until the grouting acceptance criteria (pressure and volume) are met.

Added advantage

Improved pile performance
Improved settlement and load-bearing characteristics.

SolThread

Soletanche Bachy's SolThread technique is a way of reducing the diameter or depth of an LDA pile whilst maintaining its bearing capacity.

A specially designed tool introduces a 75mm thread into a conventionally bored pile shaft. The threading process starts from the base, with the teeth being mechanically ejected with clockwise rotation of the tool. The thread forming is performed using an auto-lift programme, rotating and extracting the SolThread tool at constant pre-set rates, to produce a uniform thread with the prescribed pitch. A "crumb bucket" integrated into the base of the tool, collects the cuttings as the threading takes place. The final stage of the excavation process is the base cleaning to remove any remaining debris. The pile is subsequently reinforced and concreted as a standard LDA pile.

SolThread piles show an increase of up to 40% in load-carrying capacity with only 15% increase in concrete volume for a diameter of 750/900mm in London Clay.

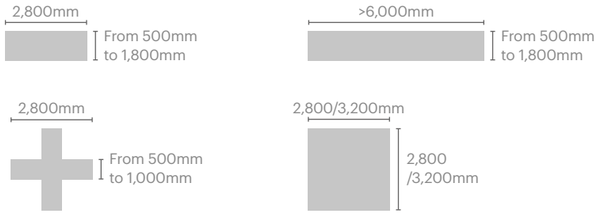
Added advantage

Higher bearing capacity
Or reduced material quantity when compared to a straight shafted pile.

Barrettes

Barrettes* are load-bearing foundation elements that can be constructed to great depths (>125m) to carry exceptionally high loads and withstand very high bending moment. The simplest geometry is rectangular, but they can also be formed in T, L, X and H shaped configurations by combining multiple rectangular units. They are often used to support mega-columns in super-structures where multiple piles in groups would otherwise be required.

Main types of barrettes



Barrettes are excavated using crane-mounted rope or hydraulic grabs, or a Hydrofraise®**. In each rectangular component, typical thicknesses range between 500 and 2,400mm, and lengths between 2,200 and 3,600mm. The excavation process using rope or hydraulically operated grabs is very similar to that of LDA piles constructed under support fluid.

During excavation with a Hydrofraise®, mud and suspended cuttings are pumped to the surface as the rotating cutters excavate the ground. At the processing plant the spoil is separated and the mud regenerated for further use in the barrette.

Principles for desanding, placement of reinforcement cages and concreting of a barrette are identical to an LDA pile constructed under support fluid, with multiple tremie tubes often being incorporated for concreting.

Advantages of the technique

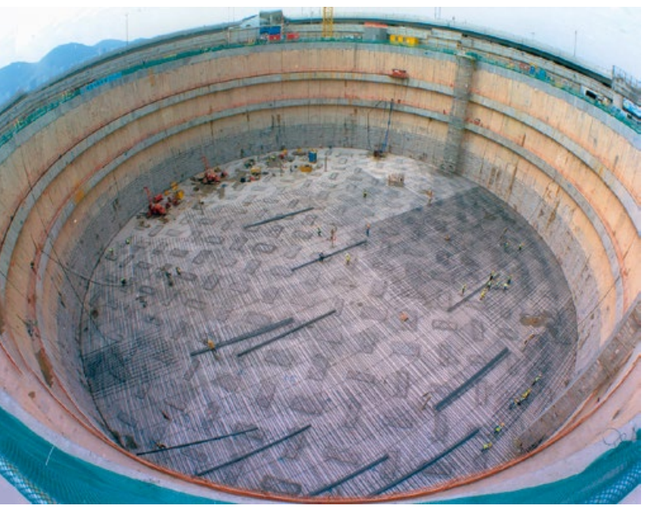
Extremely high load-bearing characteristics
Orientation of barrettes and columns can be adapted to optimise structural capacity and resist large horizontal loads.

Best ratio surface/section
Eg.: 2,700×500=6.4m²/m / 1.35m² for a barrette vs dia. 1,300=4.08m²/m / 1.32m² for a pile.

No depth limitation

VALUE ADDED BY SOLETANCHE BACHY

- Broad experience of barrette works validated by world records.
- A fleet of nearly 200 mechanical or hydraulic grabs or Hydrofraises® and 280 crawler cranes.



Reference

International Commerce Centre – MTRC Kowloon station | Hong Kong

BACHY SOLETANCHE GROUP LIMITED

In 2003, Bachy Soletanche Group Limited, the Group's subsidiary in Hong Kong, successfully completed the 20 month Kowloon station development programme. The works included the construction of a 1.5m thick circular diaphragm wall shaft of 76m diameter, plus 240 internal barrettes and 48 barrettes outside the shaft. All diaphragm wall panels and barrettes were shaft-grouted after installation to enhance the skin friction.

*Barrettes have been defined in International Standards and Codes of Practice as "bored piles". **More information upon request.

Plunge columns

Plunge columns are structural steel sections that are inserted into LDA piles, normally in the range of 1,050mm to 2,100mm diameter, while the concrete is still fresh. They can also be installed in barrettes with thicknesses normally 1,000mm or greater. They are most frequently used in "top down" or "semi-top down" basement construction.

The plunge columns can be designed to act in a temporary condition to carry slab and structural loads, or as permanent load-bearing elements that are normally encased in concrete during the "top down" process. The size of the structural element required often dictates the pile diameter. Many plunge column piles feature low concrete cut-off levels (at the bottom of the basement structure for instance), and the positional and verticality tolerances for the plunged steel sections are considerably tighter than those for drilling.

VALUE ADDED BY SOLETANCHE BACHY

- Ability to design and manufacture piling tools and manufacture a range of sophisticated hydraulic and mechanical plunge column placement frames.
- Demand for plunge columns to be inserted with increasing levels of accuracy, up to 1 in 400 for verticality and 10mm in plan position, has led to developments and innovations in equipment and techniques.

Reference

Plaza Claro El Salitre | Colombia

SOLETANCHE BACHY CIMAS + GEOFUNDACIONES

In Bogota, Soletanche Bachy Cimas and Geofundaciones, the Group's Colombian subsidiaries, carried out their first turnkey project in 2015 and 2016 to construct a new 20,000m², 4 storey basement. The "top-down" construction technique created space for a new commercial development that will be situated beneath 4 new 10 storey tower blocks. The works included a perimeter diaphragm wall and 235 low cut-off barrettes to depths of 40m each incorporating structural steel plunge columns for the support of the walls and slabs. Soft clay conditions in Bogota are particularly challenging, but the works were conducted safely with production rates twice that of the local standard. The Group exported its expertise in structural monitoring and precision control to achieve rigorous specification requirements elevating pre-existing local standards.

Large diameter rock drilling

Ø DIAMETER
From 600mm to >7,000mm

I DEPTH
From 10m to >100m

Soletanche Bachy provides a range of rotary and percussive techniques for coping with hard rock drilling, both on land and for marine works. Plant and techniques are developing rapidly and each technique has its own merits depending on the pile diameter, properties of the rock, and the depth of the socket (penetration into the hard strata) required. These drilling techniques rely on support from the expert servicing and maintenance staff that Soletanche Bachy deploys to manage the plant, tools and consumables.

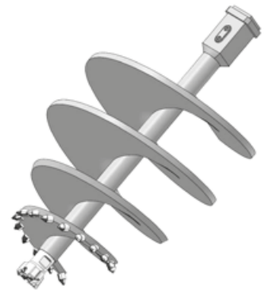
VALUE ADDED BY SOLETANCHE BACHY

- ✔ Instrumented rigs to record drilling parameters and pile verticality.
- ✔ Ability to analyse rig instrumentation to optimise design parameters and ascertain ground characteristics.
- ✔ A versatile, modern fleet of more than 280 small diameter rigs and 220 large hydraulic piling rigs.
- ✔ In-house design and method office to fit and adapt the right process for each ground condition.

Traditional rotary techniques

Rock with strengths up to 200 MPa can now be drilled using traditional hydraulic piling rigs equipped with specialised tools, such as special augers and core barrels and buckets featuring special teeth and rock roller bits. Soletanche Bachy has developed both rotary tools and techniques to cope with increasingly hard strata, but due to limits in weight and torque of the rig, maintenance, and the cost of consumables, traditional piling rigs only tend to be utilised to create sockets of a limited length in rock up to 100 MPa, after which other methods are more cost efficient and productive.

Rotary in-house tools



Down The Hole hammer drilling

Ø DIAMETER
From 600mm to >1,300mm

I DEPTH
>100m

The Down The Hole (DTH) hammer drilling is an effective way of forming sockets or dealing with boulders in hard rock up to 300MPa. DTH hammer drilling can be undertaken in dry or wet conditions but does not cope well with layers of soft material. The method relies on a bore being relatively stable because no casing is employed during the excavation process.

Compressed air requirements of the DTH hammer depend on the bit and rod diameter, the groundwater level and the altitude, but are typically between 50m³/min and 300m³/min. The up speed of the cuttings has to be over 3m/s at sea level. The air pressure depends of the bit-face geometry, the groundwater level and the depth, but typically ranges between 10 and 15 bar (+ 0.1 bar/m of water load).

Advantage of the technique

Fast rock drilling in stable ground conditions

Casing advancement systems

Casing advancement systems drill through the rock whilst simultaneously inserting casings, with a DTH hammer. These drilling techniques are therefore extremely good for digging through variable and unstable hard strata, because the bore is never unsupported. Very good verticality tolerances can be achieved and excavations can be inclined. Casing installation can be permanent or temporary.

Many proprietary systems are available. Each incorporates a pilot bit attached to the shank of a large single DTH hammer that engages a ring bit that rotates and cuts on the bottom of the casing shoe. Air flow and pressure are similar to the DTH hammer.

Advantages of the technique

Rapid excavation and continual ground support in unstable or hererogenous rock

Better control of the verticality

Installation of temporary or permanent casings in hard rocks

Ability to form under-reamed shaft beneath casing with specialised wing-bit cutting head

Cluster drills

DIAMETER
From 600mm to >3,000mm

DEPTH
>100m

Cluster drills are an effective way of forming hard rock sockets or dealing with boulders up to 300MPa under dry or wet bore conditions. They can be mounted on a traditional rig or lead system. A series of hammers are mounted in the tool. Cuttings are collected and emptied periodically from a Calyx basket situated above the tool in dry bores, or by reverse circulation in a slurry filled shaft (read more in the adjacent section).

Cluster drills are more effective at diameters greater than 600mm and are limited to approximately 2,000mm on account of the air consumption. However, hole-openers, tools incorporating a series of hammers around only the perimeter of the tool, can be used to enlarge existing pile sockets to diameters of approximately 3,000mm.

As with the DTH technique, air requirement is extremely high, especially at diameters exceeding 1.5m.

Advantages of the technique

High productivity
Particularly effective for short, dry rock sockets.

Rig compatibility
Modern kelly-mounted tools for compatibility with standard hydraulic piling rigs.

Maintenance and replacement
Smaller hammer elements readily available and relatively quick to replace. Less risk of major down-time.

VALUE ADDED BY SOLETANCHE BACHY

- Network of expert plant maintenance facilities worldwide.
- Broad experience of hard rock drilling on major projects.

Reference

Dégrad des Cannes wharf | French Guiana
BALINEAU

In 2010, Balineau, a marine specialist subsidiary of Soletanche Bachy, undertook rehabilitation works to repair and improve the petroleum wharf at Dégrad des Cannes. The offshore works, performed from a pontoon, were logistically challenging as it was essential to maintain deliveries of petroleum to the terminal throughout the project. To socket the 1,200mm diameter piles into the hard diorite rock, a cluster drill featuring 9 pneumatic hammers was mounted on a lead. Specially designed and manufactured guideframes were utilised to ensure that positional tolerances were achieved.

Reverse Circulation Drilling

DIAMETER
From 600mm to >7,000mm

DEPTH
>100m

Reverse Circulation Drilling (RCD) is a robust and well-established technique, which utilises a rotary cutting head and mud reverse circulation with airlift.

The drill string (consisting of drill rods, stabilisers, bottom hole assembly and rotary cutting head) can be mounted on a lead system or "Pile Top Rigs" that clamp to a casing.

The rock is normally drilled using water or a drilling mud, and the cuttings are transported back to the surface thanks to the injected compressed air introduced inside the drill rod just above the rotary cutting head.

Compressed air requirements, typically 10-30m³/min at 13-25 bar, are less than for other rock drilling techniques. The technique relies on rotation and pressure being applied to the rock via rollers mounted in the cutting head.

Advantages of the technique

Extremely large diameters and depths possible
Depth and diameter limited by rig line-pull capacity.

Flexible technique
RCD drilling can be set up on a variety of carriers specialised for both onshore and offshore piling works.

Mechanically simple machinery and tools
Relatively low maintenance and down-time.

VALUE ADDED BY SOLETANCHE BACHY

- A modern, versatile fleet of more than 20 RCD rigs and 25 oscillators.
- In-house manufacturer of leads compatible with carrying RCD rotary heads and drill-string.
- Instrumented rigs to record drilling parameters and pile verticality.
- Ability to analyse rig instrumentation to optimise design parameters and ascertain ground characteristics.
- Technique can be supplemented with a directionally drilled pilot hole for extremely accurate bores.
- Broad experience of RCD works both onshore and offshore around the globe.
- A dedicated laboratory for mud and concrete mix design.

Reference

Midfield Terminal | Hong Kong
BACHY SOLETANCHE GROUP LIMITED

For the Midfield Terminal of the Hong Kong International Airport, Bachy Soletanche Group Limited, the Group's subsidiary in Hong Kong, carried out all of the foundation works. A total of 221 large diameter bored piles were constructed between 2011 and 2012 using Reverse Circulation Drilling techniques under bentonite. Piles ranged between 1.5 and 3m in diameter and reached depths of 118m.
The works, located "airside" in between 2 operational runways, were logistically challenging with stringent restrictions on access, machinery movement and raw material deliveries.
To fulfil the programme requirements, 10 "pile-top" rigs and 15 cranes were utilised, with the project finishing 10 months ahead of schedule.

Continuous flight auger piles

DIAMETER
From 300mm to 1,500mm

DEPTH
Up to 52m

Continuous Flight Auger (CFA) piles are formed using a full-length, segmental, hollow stem auger (or a combination of augers and a kelly pole extension for deeper piles). Ground support is provided by the auger and spoil generated during the drilling process, eliminating the need for temporary casings or drilling mud.

Concrete is introduced to the base of the excavation through the hollow stem and fill the excavation as the auger is raised up. The concrete pressure must be sufficiently high and the auger must remain embedded in the freshly placed concrete to ensure there is no risk of soil collapse contaminating the pile shaft.

Unlike the LDA process where cages are suspended in the pile bore, the reinforcement is plunged through the wet concrete to conclude the pile construction process. Optimised concrete rhelogy is crucial especially in longer reinforcement cages.

CFA piles can be utilised as bearing piles for structural foundations, or to create embedded retaining walls.

CFA techniques have evolved rapidly over the past 30 years and Soletanche Bachy has been at the forefront of these technical developments.

Advantages of the technique

High productivity
Particularly where ground has granular, water-bearing strata to a significant depth.

Rapid mobilisation
Modern CFA rigs tend to be very quick to mobilise and operations are relatively compact.

Environmentally friendly technique
Relatively low noise and vibration compared with other techniques.

VALUE ADDED BY SOLETANCHE BACHY

- A modern, versatile fleet of more than 150 CFA piling rigs.
- Instrumented rigs to record drilling parameters, pile verticality and concreting parameters.
- Ability to analyse rig instrumentation to optimise design parameters and ascertain ground characteristics.
- Longer reinforced lengths possible due to innovative concrete mix designs from in-house laboratory.
- Patented developments to the base technique such as Starsol® and T-Pile®.
- Specialist plant and R&D departments continually developing techniques and offering project support.

Typical construction sequence

1.
The rig is set up on the pile position and the hollow stem auger is positioned prior to the commencement of drilling.

2.
As the bore is advanced the spoil remains on the auger and provides temporary ground support.

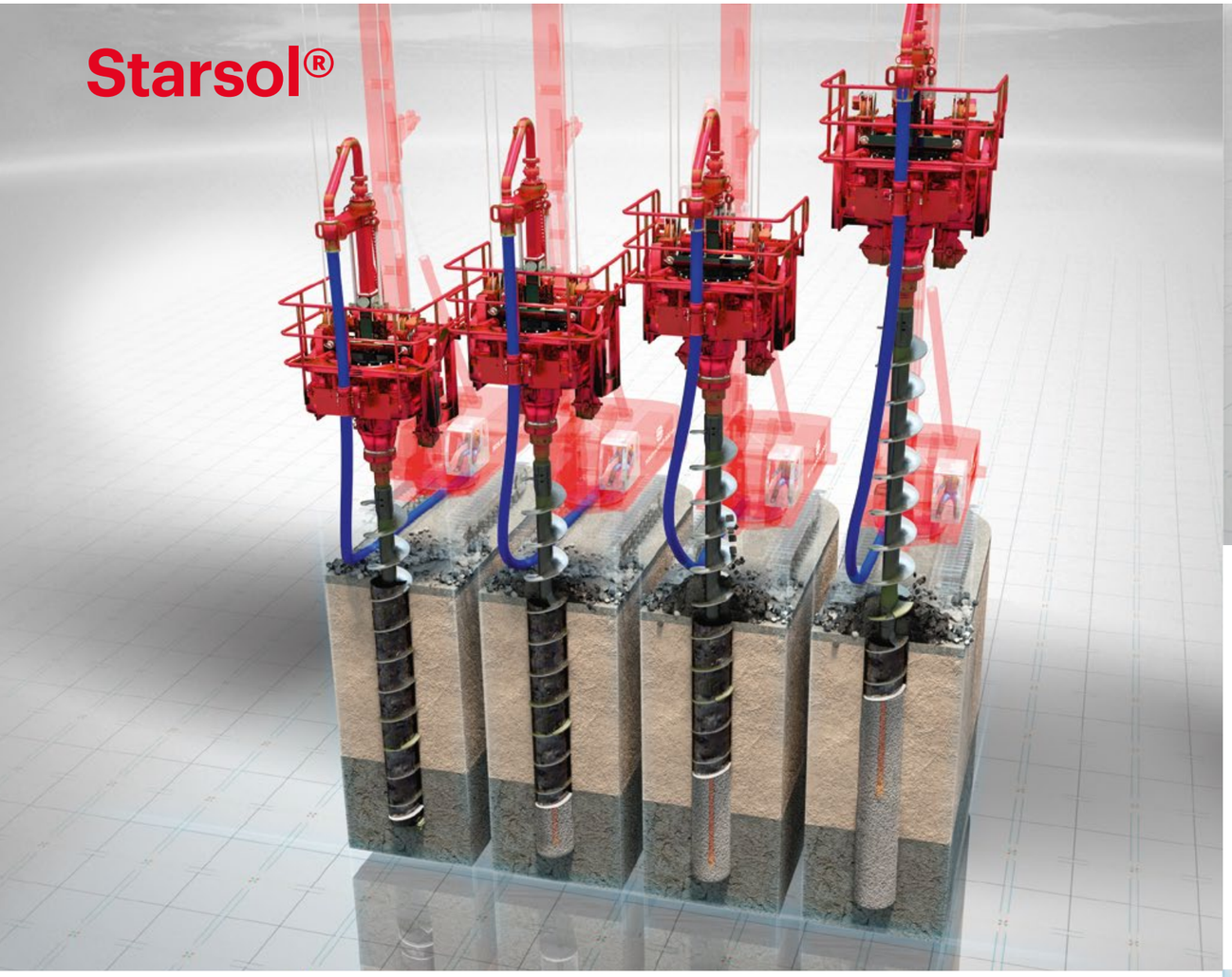
3.
At the required toe level, the plug is ejected and concreting commences.

4.
Concrete is pumped through the hollow auger stem, filling the pile from its base upwards during the extraction process.

5.
Once the auger has been withdrawn, the pile head is cleaned to expose the fresh fluid concrete through which the cage is plunged.

6.
The pile is completed.

Starsol®



DIAMETER
From 400mm to 1,500mm

DEPTH
Up to 52m

Soletanche Bachy's Starsol® (and RodioStar) piles are a patented development of the traditional CFA technique in relation to the concreting process and the ability to socket into rock with strengths up to 50MPa.

Starsol® piles are CFA piles that are concreted using a hydraulically activated plunger tube placed inside the hollow auger stem. The end of the tube aligns with the bottom of the auger during excavation and can be fitted with cutting teeth for creating sockets in hard strata. On completion of the boring, the tube is extended by operating hydraulic rams on a specially adapted rotary drive as the augers are withdrawn.

Starsol® piles are recognised by a number of standards to offer superior performance, and consequently enhanced design parameters are permitted in calculating pile capacity.

Advantages of our technique

Enhanced pile parameters in design
Skin friction and end-bearing parameters can be increased to offer savings in pile length and materials.

Improved concreting
Plunger tube placement allows concrete design coefficients to be increased.

Rock sockets
Teeth mounted around the plunger tube opening in the lead auger allow for rock socketing.

T-Piles®

DIAMETER
From 420/620 to 820/1,020mm

DEPTH
Up to 50m

T-Piles® are a further innovation where CFA or Starsol® piles can be constructed to incorporate a thread around the shaft of the pile. In suitable ground conditions a cutting tooth is mechanically deployed by the operation of the plunger tube.

Positive rotation of the auger string during extraction enables a spiral thread to be cut around the shaft thus allowing significantly increased capacity to be carried by the pile with minimal additional concrete provision.

Advantage of our technique

High-bearing capacity or reduced material quantity
When compared to a traditional straight-shafted pile.

Reference

Philharmonie de Paris | France
SOLETANCHE BACHY PIEUX

In the Parc de la Villette, in Northern Paris, a major music complex opened to the public in 2015. Soletanche Bachy Pieux, a specialist subsidiary of Soletanche Bachy, constructed 700 Starsol® piles at diameters between 520 and 1,220mm and to depths of up to 28m.

Rotary displacement piles

DIAMETER
From 300mm to 800mm

DEPTH
Up to 32m

Displacement Screw Piles (DSP), also known as rotary displacement piles, are created in a similar method to CFA piles. Instead of a full length hollow auger, a shorter displacement tool is followed by hollow stem drill rods to reach the required depth. As piles are bored, the specially designed hollow tool displaces the surrounding soil laterally, and consequently high torque and pull-down rigs are required. Having reached the required depth, concrete is pumped through the hollow drill string and introduced from the base of the bore whilst the tool and rods are extracted. Cages are inserted after the concreting process.

Rotary displacement piles are typically utilised for lightly-loaded structures, storage areas, residential developments, and redevelopment of brownfield sites. The technique is particularly appropriate in loose granular strata (SPT<50), chalks and clays (SPT<30).

Advantages of the technique

Very low quantities of spoil
Particularly advantageous in contaminated ground.

Environmentally friendly technique
Low noise and vibration, optimised concrete volumes as ground parameters improved with soil displacement.

Time saving
Equipment quick to mobilise with relatively high production rates.

VALUE ADDED BY SOLETANCHE BACHY

- A fleet of more than 60 modern piling rigs with high torque and pull-down.
- Instrumented rigs to record drilling parameters, pile verticality and concreting parameters.
- Ability to analyse rig instrumentation to optimise design parameters and ascertain ground characteristics.
- Longer reinforced lengths possible due to innovative concrete mix designs from in-house laboratory.
- Specialist plant and R&D departments continually developing techniques and offering project support.
- Design and manufacture of own tools.
- Developments to the base technique such as TSP, DSP_{STAR}, TSP_{STAR} and twin diameter piles.

Typical construction sequence

1.
The piling rig is set in position, and the end cap is placed in the end of the hollow drill stem.

2.
As boring is undertaken, the specially designed tool first loosens and then displaces soil both laterally and vertically.

3.
Once the tool reaches the required depth, the sacrificial end cap is ejected and concreting commences.

4.
The pile is concreted through the hollow drill stem in the same way as a CFA pile.

5.
On completion of the concreting, the pile head is cleared of debris and the cage is inserted.

6.
The pile is completed.

Threaded Screw Piles

DIAMETER
From 270/420mm up to 720/870mm

DEPTH
Up to 32m

TSP (also known as Screwsol) are Threaded Screw displacement Piles where a thread is formed by positive rotation of special tool during extraction. The thick threads increase the effective diameter of the piles reducing the relative quantity of concrete for a given load resistance. Soletanche Bachy has developed its own derivative tools that offer superior performance and better wear resistance.

Added advantage

Higher effective diameter
Increased bearing capacity or reduced material quantity when compared to a straight-shafted pile.

Reference

Toy factory | Hungary
HBM

Near Nyíregyháza, in Eastern Hungary, a toy factory opened in 2015. HBM, the Group's subsidiary in Hungary, constructed 6,270 TSPs of 330/500, 430/600 and 530/700mm in diameter and 614 CFA piles of 600mm diameter. The pile depths were up to 15m.

Continuous Helicoidal Displacement piles

DIAMETER
From 300/600mm or 400/700mm

DEPTH
>30m

CHD® are Continuous Helicoidal Displacement piles. The tool is made from a highly efficient multi-flight bullet ended shaft requiring a high torque rotary head. The tool is reversed on extraction and the cutter follows the same path as it did during the insertion. This technique produces the lowest concrete volume to effective diameter ratio.

Added advantage

Higher effective diameter
Material quantity reduction of up to 40% when compared to a traditional straight-shafted rotary bored pile with same bearing capacity.

DSP_{STAR} and TSP_{STAR}

DIAMETER
From 270mm up to 820mm and
from 270/420mm up to 720/870mm

DEPTH
Up to 50m

DSP_{STAR} and TSP_{STAR} (or Refsol) are DSP and TSP piles constructed with a plunger tube built into the tool to enhance concrete quality and pile parameters even further.

The technology, derived from the Starsol® process, also allows for the displacement piles to be socketed into relatively hard ground on account of teeth that can be mounted around the plunger on the tip of the auger.

Added advantage

Enhanced design parameters
Cost saving thanks to enhanced skin friction and bearing capacity parameters. Design capacity for the concrete can be increased.

Driven piles

DIAMETER
From 300mm to 5,000mm

DIAGONAL
From 250mm to 700mm

DEPTH
>70m

There are a variety of structural elements that can be driven, vibrated or jacked into the ground, forming a pile with a known resistance. These types of pile can displace the soil laterally and vertically in certain ground conditions, improving the soils characteristics.

Driven piles can be fully structural members, or incorporate a driven element that is later filled with concrete or grout to supplement the structural capacity. Driven piles are often inclined to accommodate large horizontal forces, and can be installed by a wide range of equipment. Jacking units, cranes (with or without leads) and traditional piling rigs can all be used.

Driven piles are capable of achieving relatively high working loads in a variety of subsoil conditions regardless of groundwater levels. Typically piles are up to 50m in length. Cranes or rigs are normally quite large, and incorporate top-drive diesel or hydraulic hammers to drive the pre-manufactured pile, or the steel or concrete casing or shell. Driven piles are usually installed to established criteria (e.g., minimum blow count per unit penetration, and sometimes with a minimum penetration requirement) to ensure that the driving resistance and hence the designed bearing capacity is achieved. In variable subsurface conditions, pile lengths may vary, but many types of driven pile are jointed or easily cut to cater for this.

Advantages of the technique

Efficient construction process
Particularly applicable in soft, saturated ground where high production rates can be achieved. No sequencing constraints as for rotary bored techniques whilst waiting for piles to cure.

Particularly suited to brownfield re-development
In contaminated ground, large cost savings arise from minimising the volume of spoil disposal, and coatings can be pre-applied to protect the piles in agressive conditions.

A driven pile is a tested pile
Piles driven to a known resistance during the installation process.

Seismic resistance
Large diameter driven piles are frequently utilised to resist seimic forces in earthquake prone regions.

VALUE ADDED BY SOLETANCHE BACHY

- A modern, versatile fleet of more than 280 crawler cranes and cable excavators, 50 leads, 20 piling rigs with rotating masts, 20 specific driving rigs, 50 hammers and jacking units.
- Soletanche Bachy's fleet includes hydraulic, low drop-height rigs and super-silenced and remotely operated quiet hammers.

Driven pre-manufactured piles

These piles are formed from structural members capable of withstanding the full-bearing capacity required as soon as they have been installed. They are generally very quick to install, and cost effective in most ground conditions. There are two main types of driven pre-manufactured piles; prefabricated reinforced concrete and steel tubes.

Reference

Isaac Newton Building | United Kingdom

ROGER BULLIVANT

In the United Kingdom, the University of Lincoln is carrying out a major campus development programme. The new prestigious Isaac Newton Building will become home to the Computer Science, Engineering, Mathematics and Physics Departments. In 2016, Roger Bullivant, a local specialist subsidiary of Soletanche Bachy, constructed nearly 350 consisting of 250mm and 300mm square precast concrete driven piles, manufactured at the company facility.

Pre-cast concrete piles

SOLID SECTION
From 240×240mm to >500×500mm

HOLLOW PRE-STRESSED DIAMETER
Up to 1,200mm

DEPTH
>50m

The most predominant type of driven pile offered by Soletanche Bachy is the pre-cast concrete pile. This pile may be used for all types of structures and foundations, but typical applications include housing and industrial buildings, bridges and pylon foundations.

Piles are supplied in standard segment lengths from 1.5m to 15m and can be designed to accommodate compressive, tensile and bending forces by incorporating moment transfer joints. The pile section shape may vary, or be hollow in the case of the pre-stressed "Spun" pile. The piles need to be able to withstand considerable handling and installation forces, and can be installed vertically or inclined.

Further specialised equipment makes it possible to install precast piles in areas of restricted access or low headroom, and jacking systems can be employed to eliminate vibration.

VALUE ADDED BY SOLETANCHE BACHY

- Large prefabrication and storage facility for the reliable supply of high quality pre-fabricated concrete piles.
- In areas where concrete quality or supply is challenging, a factory manufactured, quality controlled product can be guaranteed.
- Useful in very low temperature applications where in-situ concreting would be a risk to structural integrity of the pile.
- Range of prefabricated element lengths to minimise requirements for trimming and material waste, thus maximising cost-efficiency.

Driven steel tubes

⌀ DIAMETER
Up to 5,000mm (vibrated)

I DEPTH
>70m

Tubular steel piles are also frequently used across the Soletanche Bachy subsidiaries. They are especially versatile in offshore applications and quay work, and they can be installed using vibratory or percussive techniques. They can be installed vertical or inclined to withstand high lateral forces. Typical applications for the inclined tubes would be on a windfarm foundation or offshore berthing structure. Driven steel tubes can also be manufactured with clutches to allow sheet piles to be placed between successive tubes to create a combi-wall. Utilisation of an oversize shoe also allows for the external circumference of a tube to be grouted during or after installation.

Other types

Around the globe, other types of prefabricated driven piles are regularly installed by the Soletanche Bachy subsidiaries including:
› Spigot-jointed Ductile Iron Piles
› Steel H Piles
› Timber piles

Driven cast in-situ piles

⌀ DIAMETER
Up to 750mm

I DEPTH
>50m

These piles are formed by driving a temporary (or occasionally permanent) thick-walled steel tube, fitted with a water-tight sacrificial end-plate. Upon reaching the required driving resistance, reinforcement cages and concrete are introduced into the steel casing tube. As soon as the concreting operation is complete the tube is normally vibrated out for re-use, leaving the concrete or grout in contact with the ground.

As well as not generating any spoil, the cast in-situ construction process also provides a tight bond between the concrete and the surrounding soil, and can limit the potential of vertical migration of contaminates on brownfield sites. Casings can also be incorporated permanently in particularly aggressive ground conditions.

Depending on the driving tubes and end-points utilised, some obstructions or weak rock bands can be driven through, and vertical or inclined piles can be installed. In heterogeneous ground conditions, additional pile length and bearing resistance can be gained by splicing steel tubes with an in-situ welded connection.

VALUE ADDED BY SOLETANCHE BACHY

- ✔ Specialist manufacturer of lead systems and diesel and hydraulic pile hammers.
- ✔ Innovative equipment design and fabrication provide greater operational reach and flexibility, minimising rig set-ups and optimising production.

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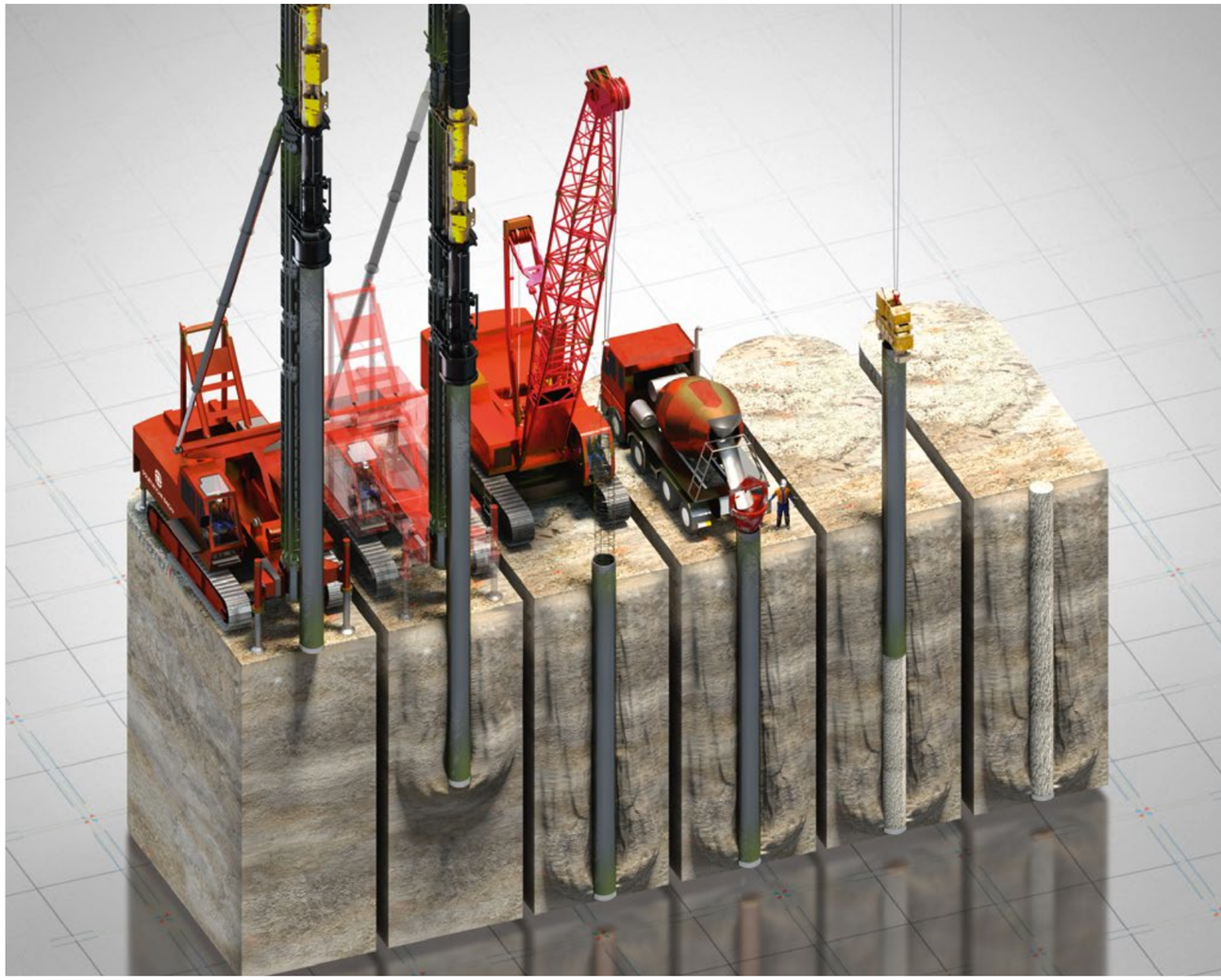
Typical construction sequence (driven cast in-situ pile)



1. The temporary steel drive tube, fitted with sacrificial end cap, is positioned.

2. The tube is driven into the soil using a top-drive diesel or hydraulic hammer.

3. After reaching the required driving resistance or depth, the reinforcement cage is inserted.

4. The dry bore is concreted using a tremie tube.

5. The temporary steel drive tube is withdrawn (normally with a vibrator) leaving behind the sacrificial end cap.

6. The driven cast in-situ pile is completed.

Reference

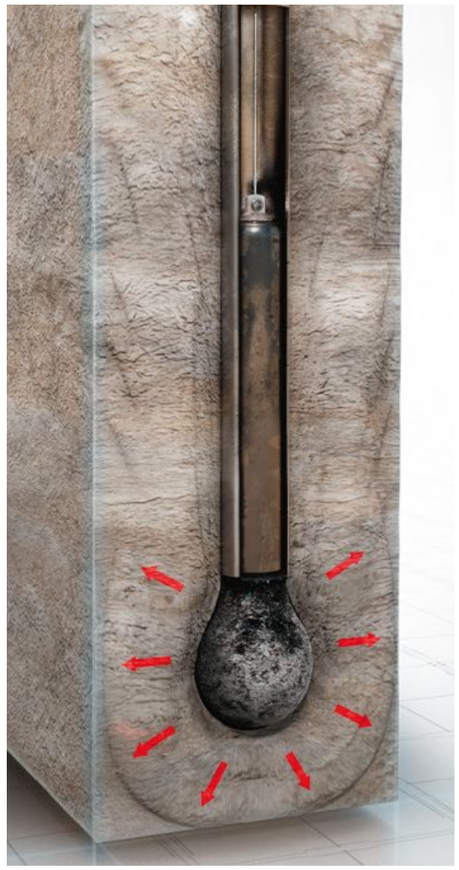
Niagara Windfarm | Canada
BERMINGHAM

In 2015, a joint venture including Bermingham Foundation Solutions, the Group's subsidiary in Canada, undertook the Niagara Windfarm project in Ontario, Canada. The JV relied on Bermingham leads, hammers and expertise to install the foundations for 32 new wind turbine bases. The project was logistically challenging, with each turbine being situated in remote agricultural areas and spread out across the entire Niagara district. Each turbine base incorporated a circular design of 48 piles, with 2 piles raking outwards and 1 pile raking inwards consecutively around the perimeter. The 400mm close-ended tubes were driven to depths of up to 60m, with multiple tube lengths being spliced in-situ, and the piles were then reinforced and tremie concreted. The short lead-in time and programme period were challenging to tube, labour and plant procurement. At peak, 7 crane/hammer combinations were utilised simultaneously to successfully deliver the project on time.

Driven Cast In-Situ piles with expanded base (DCIS)

This traditional technique (also known as Franki piling) is still used by Soletanche Bachy in certain subsidiaries around the globe where the technique is well established and important to the local market.

It remains a reliable form of pile because of the ground verification whilst driving the casings, and the enlarged base can offer savings in material quantities when compared to straight-shafted driven and cast in-situ piles. The technique is particularly suitable in soft or granular stratum, in contaminated land where very little spoil is generated, and in remote areas where noise and vibration do not present an environmental concern. Simple mechanical rigs that are specific to the technique tend to be used.



INSTALLATION OF A DCIS PILE

1. A charge of zero-slump concrete is poured into the bottom of the temporary steel driving tube that is placed on the pile position. A drop hammer is then driven onto the concrete, forming a watertight concrete plug that then drives the steel tube with subsequent blows.

2. Once the required resistance or set is achieved, the tube is clamped in position and the concrete plug is subsequently driven into the ground by the drop hammer creating the enlarged base.

3. A rebar cage is placed into the bore and the shaft can be concreted using wet or dry concrete.

4. With wet concrete the casing can be removed after the concreting process. If dry concrete is utilised, an enlarged shaft can also be created by ramming concrete in layers with a drop hammer inside the reinforcement cage whilst simultaneously withdrawing the temporary casing.

VALUE ADDED BY SOLETANCHE BACHY

- ✔ Technical support from expert plant department and in-house driven pile equipment manufacturer.
- ✔ Faster and more efficient services thanks to global presence and sustained expertise in local markets.

Constrained access & low-headroom works

Soletanche Bachy offers a versatile range of specialist piling techniques to facilitate drilling and foundation construction in logistically challenging and highly constrained site conditions. Site operations are supported by expert plant and equipment design and manufacture, and constant innovations coming through an ongoing commitment to research and development.

Micro and minipiles

⌀ MICROPILES DIAMETER
From 100mm to 300mm

⌀ MINIPILES DIAMETER
From 300mm to 600mm

I DEPTH
>75m

Micropiles are drilled piles with a diameter less than 300mm or driven displacement piles with a diameter less than 150mm. The load-bearing element of a drilled micropile consists of steel bar, a steel tube, or an H-type profile inserted into cement grout, mortar or micro-concrete for load transfer. Often the structural component is a "self-drilled" hollow bar fitted with a sacrificial drill bit with grout flushed through its centre. In a micro-displacement pile the steel or precast concrete load-bearing component is driven or vibrated in direct contact with the ground.

Minipiles are normally considered to be small diameter drilled piles with diameters in excess of 300mm but less than 600mm. The techniques, plant and equipment employed tend to be similar to those adopted for the micropiling techniques. Soletanche Bachy has a wide range of micro and minipiling techniques to cater for all ground conditions.

Advantages of the technique

Building serviceability
Repairs and modifications to existing structures with small, agile rigs to extend their working life or change their function without the need for demolition and reconstruction.

Access to remote or logistically challenging sites
Specialist minipile equipment deployed to minimise temporary works and access provision that would be uneconomic for conventional plant. Compact machines allow maintenance of transport infrastructure without closure of the asset.

Can be used in all types of soils

VALUE ADDED BY SOLETANCHE BACHY

- A diverse modern fleet of 280 mini-rigs including electrically powered machines to eliminate waste combustion gases in confined working environments.
- Patented techniques and equipment, supported by expert plant design and manufacturing capabilities.
- Industry leader in the design and manufacture of safety guards, emergency cut-out devices and integrated operator access platforms.
- Diverse range of techniques to serve all ground conditions.

Reference

Provo Temple | United States
NICHOLSON CONSTRUCTION

A fire destroyed the Mormon temple in Provo, Utah in December 2010, leaving only the brick facade and the rough sandstone foundations. Entrusted to Nicholson Construction, the Group's subsidiary in the United States, the renovation project included the underpinning of the historic building structure and the creation of three underground levels. 136 micropiles with a diameter of 244mm up to 17m deep were constructed. The technically complex project was visually impressive. During construction of the micropiles and the excavations, the temple appeared to be floating in the air.

Loads typically up to 1,500kN can be carried by these piles depending on pile length and ground conditions, but normally the capacity is assumed to be derived exclusively from lateral friction. Due to the slenderness of the pile and the limited quantities of steel, careful design consideration needs to be given to the structural failure of the piles, and also buckling in poor ground. Vertical deformations tend to be greater than for larger diameter bored piles. In some applications such as underpinning works, partial or complete load transfer can be carried out by pre-jacking piles to minimise permanent differential settlement. Compressive or tensile loads can be carried at large angles (>20° to the vertical).

Traditionally minipiling or micropiling techniques have been used in restricted access or low-headroom situations. They are often used for underpinning existing foundations, anchoring basement slabs against uplift, and drilling through obstructions. The techniques are often necessary for the installation of foundations within existing factory units for heavy machinery, for retro-fitting basements, and for new foundations and slope stabilization in active road and rail environments.

Hi'Drill®

Hi'Drill® is a patented, high-performance boring system created by Soletanche Bachy, featuring a rotary head which resonates the drill string. Unlike conventional vibrating heads which operate at low frequencies (0-60Hz), Hi'Drill® heads use higher frequencies (0-150Hz). Hi'Drill® is particularly suitable for borehole drilling, for the installation of anchors, soil nails, and micropiles. It is highly efficient when used in heterogeneous soils containing hard and soft strata.

Hi'Drill® heads can be effectively mounted on a variety of base carriers from compact 2t purpose-built frames to 60t piling rigs, to meet specific project needs.

VALUE ADDED BY SOLETANCHE BACHY

- Works can be undertaken in extremely low-headroom and constrained access conditions.
- Rapid and versatile drilling technique in all ground conditions including rock and obstructions.
- Reduced vibratory transmission to adjacent structures or services.
- Rates in excess of 300m per day with the 15m long-stroke system.
- Rigs equipped with rod-handlers eliminating manual handling hazards.

Low-headroom large diameter bored piles

Large diameter bored piles can be constructed in limited headroom using carriers with a shortened mast and kelly bar. An advantage of the technique is that the telescopic kelly bar enables pile depths to far exceed the operating headroom, thus allowing pile capacities to be greater.

Continuous Flight Auger (CFA) piles can be formed using rigs with shortened masts to fit inside warehouses and under motorway bridges for example. Despite being relatively fast and efficient, the pile depth is limited by the height of the mast carrying the auger string.

In Sectional Flight Auger (SFA) piles, small lengths of hollow auger are added progressively during the excavation process. In these piles, concrete is pumped to the base of the pile, and special quality considerations are required during the concreting or grouting process as sections of auger are removed.

Maximum depth and diameter is controlled by the available headroom, the ground conditions and the torque of the rigs employed. The size of the carrier increases proportionally to the power and torque of the rotary head, so although standard size LDA piles (up to 3m diameter) are possible in areas of restricted headroom with shortened masts, pile capacity is limited by the extremity of the access constraints. Purpose-built rigs, typically 2×1.5m in plan and in the 4 to 8 tm of torque range, can install piles up to 750mm diameter in <4m of headroom, and are ideally suited to working in basements.

Advantage of the technique

Increased bearing capacity in low headroom
Specialised plant and techniques offer considerable savings and efficiencies compared to traditional minipiling techniques.

VALUE ADDED BY SOLETANCHE BACHY

- A modern and versatile fleet of more than 20 short-mast rigs and 40 high-torque mini-rigs.
- Particular expertise and experience in the design, modification and manufacture of specialised plant to adapt to individual project requirements.
- Ability to optimise quality and design with sophisticated rig instrumentation and an experienced in-house design capability.

Reference

London Bridge Station | United Kingdom
BACHY SOLETANCHE

Between 2012 and 2016, Bachy Soletanche undertook one of its largest and most challenging restricted access piling contracts. With a recent 50% growth in passenger numbers from Gatwick Airport, London Bridge Station now handles more than twice the number it was designed for. The station redevelopment involved creating new platforms for more trains, building a new concourse and creating a bigger, better station for passengers. The Group's subsidiary in the United Kingdom installed 1,475 bored piles with diameters 508/450 and up to 25m deep, 11 bored piles with a diameter of 1,200mm, up to a maximum depth of 64m and 309 piles with a diameter of 900/1,050 plus 134 piles with a diameter of 1,050. The works were carefully sequenced, with restricted access piles being constructed within the existing railway arches previously occupied by retail and commercial businesses. The foundations for the new parts of the station were built in advance of the demolition of redundant brick viaduct sections.

Reference

Résidence Hôtelière du Rail | France
SOLETANCHE BACHY

In France, the Résidence Hôtelière du Rail provides new accommodation for the SNCF staff above the pre-existing Montparnasse railway station. The foundations, undertaken by Soletanche Bachy France, were 1,000mm × 2,800mm barrettes to depths of 24m, constructed in just 5.5m of headroom. The special compact, low-headroom Hyrofraise® operated in very close proximity to both operational train lines and essential live services, in a busy commuter environment. All of Soletanche Bachy's technical and operational expertise was essential for the safe and successful delivery of the project.

Low-headroom barrettes

PANEL WIDTH
From 500mm to 2,400mm

PANEL LENGTH
2,800mm

DEPTH
>75m

Soletanche Bachy has also designed and manufactured a range of compact, low-headroom Hydrofraises® and grabs. Barrettes up to 75m in depth are achievable in 5m of headroom.

Advantages of the technique

Superior load-bearing characteristics
Technique more efficient than an equivalent group of low-headroom piles in certain applications. Consequential savings in concrete and costs of pile cap.

Low vibration
Minimal disturbance adjacent to existing structures.

VALUE ADDED BY SOLETANCHE BACHY

- A fleet of more than 10 low-headroom hydraulic grabs or Hydrofraises® specially designed and manufactured by in-house teams.
- Fully instrumented plant and directional drilling capabilities for precise excavation and verticality control.

Embedded bored pile retaining walls

Ø DIAMETER
From 300mm to >2,500mm

I DEPTH
>50m

An embedded retaining wall is a vertical structure installed for ground retention prior to subsequent excavation. Unlike gravity retaining walls, the weight of a slim embedded retaining wall has a negligible effect on its capacity to balance the pressures. It holds back the pressures exerted by the soil, water and existing structures. Depending on the requirements of a project, embedded retaining walls may be designed as a cantilever structure, or supported by struts or ground anchors installed through the wall during excavation.

Embedded bored pile retaining walls can either be continuous (secant) if a watertight structure is required, contiguous (closely spaced) if the groundwater level is low, or discontinuous if the groundwater level is low and soils are relatively stable.

For secant walls, LDA, Cased Secant Pile or RCD techniques are commonly used. The CFA technique can also be used to create secant walls of limited depth on account of the verticality tolerance that can be achieved. Contiguous and discontinuous walls are commonly formed with CFA or driven pile techniques.

Advantages of the technique

Geometry more flexible
Than a diaphragm wall.

Especially suitable for sites with constrained access as mud plant is much smaller

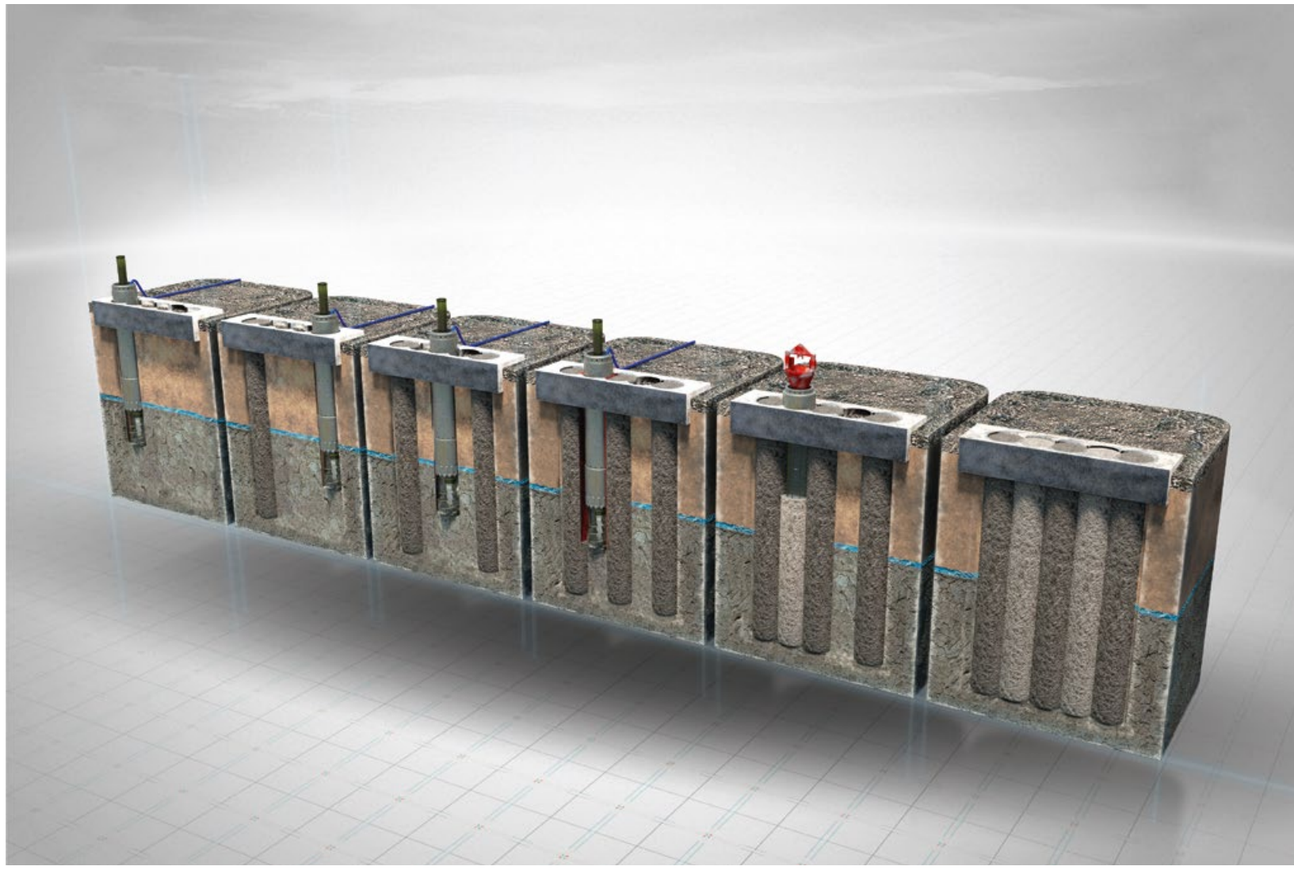
Techniques adapted to all ground conditions

Load-bearing capacity
Vertical loads can be carried by retaining wall elements.

VALUE ADDED BY SOLETANCHE BACHY

- Instrumented rigs to record drilling parameters and pile verticality.
- Ability to analyse rig instrumentation to determine precise ground characteristics and optimise design parameters.
- A dedicated laboratory for mud and concrete mix optimisation.
- Experienced in-house design team to add client value through front-end “optioneering”.

Typical construction sequence (secant pile wall)



1.
A temporary reinforced concrete guidewall is constructed in advance of the piles to locate them and assist with the verticality of the pile bores. Once the guidewall has cured, primary piles can commence with normal rotary bored techniques.

2.
Additional primary piles are bored. These are normally un-reinforced.

3.
A sequence is followed such that consecutive primary piles are sufficiently spaced prior to initial concrete cure. The number constructed is dictated by the optimum concrete strength for subsequent excavation of the secondary piles.

4.
The secondary piles are drilled to depth using sectional casings equipped with a cutting shoe for casing to core through the primary piles either side. Concrete and spoil are removed periodically from inside using traditional tools.

5.
A structural cage element is installed into the bore, and the secondary piles are concreted.

6.
Secondary piles are installed to complete a section of wall. Often primary piles at the extremities of each working area are 'pre-cut' and backfilled in anticipation of the future continuation. As the concrete hardens in the primary pile, this “dummy pile” ensures the verticality of the first secondary pile in the new work area.

Secant pile walls

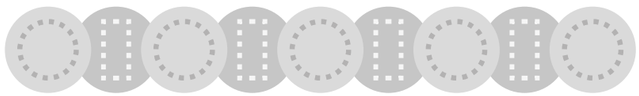
A secant pile wall is formed by the construction of alternating primary (female) and secondary (male) piles, where the secondary piles partially cut through the primary piles either side to form a continuous impervious structure.

Secant walls are frequently used as an alternative to diaphragm walls where obstructions are anticipated, or in urban basement projects where space is limited. When compared with a diaphragm wall basement, they can be more flexible in shape, and offer a relatively compact operation in relation to the size of the mud plant set-up.

Depending on structural requirements, the specification of the primary pile can change. Hard-soft walls incorporate a plastic bentonite-cement slurry in the primary piles, hard-firm walls a C15/20 (2,000 psi) concrete, and hard-hard walls a full strength structural concrete (typically C32/40 [4,000 psi]). In the majority of cases the primary piles are un-reinforced, but in exceptional circumstances, further capacity can be gained by inclusion of rectangular cages. In designing the wall, the spacing between the secondary piles is dictated by both structural requirements and depth (an overlap being required at all times whilst considering drilling tolerances).

Sequencing the piles is critical in the case of a hard-firm or hard-hard wall, as both productivity and quality (verticality) will be determined by the ease in which the secondary piles can be installed through the adjacent primary piles. Casing insertion or extraction is often serviced by hydraulic oscillators or rotators in deeper foundations.

Secant pile wall - Unreinforced primary piles



Secant pile wall - Reinforced primary piles

Reference

Gobet Tunnel | Switzerland
SOLETANCHE BACHY

In 2012 and 2013, Sif Groutbor, the Group's subsidiary in Switzerland, constructed >5km of secant pile retaining walls for the tunnel portals and underpass on the upgrade of the Gobet Tunnel. The job was technically demanding, and the seismic resistance dictated by the design meant that unlike conventional secant walls both the primary and secondary piles were reinforced, meaning extremely accurate digging tolerances were required. Helical shear steel was not permitted by the codes and reinforcement cages instead incorporated over-lap rings and links at designated spacings.

Cased Secant Piles

The Cased Secant Pile (CSP) system has been developed to combine the more cost-effective CFA technique with temporary casings that are more traditionally associated with rotary bored piling methods. A twin superimposed rotary drive system rotating in opposite directions allows soil extraction and casing installation simultaneously. The method is particularly suitable for basement walls adjacent to existing structures.

Advantages of the technique

Relatively high productivity
Speedier operation than the more traditional "kelly/casing" rotary bored pile method.

Protection of adjacent infrastructure
Reduced risk of "flighting" and damage to existing infrastructure when compared to traditional CFA techniques.

Superior performance to the traditional CFA technique
Better ultimate appearance and verticality tolerances than with an uncased CFA secant wall.

Enhanced schedule

VALUE ADDED BY SOLETANCHE BACHY

- A wealth of project experience and instrumental in developing CSP techniques and equipment since their conception.

Reference

Parkway Newbury | United Kingdom
BACHY SOLETANCHE

In 2009, Bachy Soletanche, the Group's subsidiary in the United Kingdom, completed the Parkway project in Newbury. The works included bearing piles and a perimeter secant wall for a 2-storey basement car park. Services and other physical constraints resulted in an irregular basement geometry, ideally suited to a bored pile solution. 452 piles formed the walls of the basement. Unreinforced 900mm diameter primary CFA piles, and heavily reinforced 880mm diameter secondary CSP were installed to depths of 18m. 1,388 internal 450mm and 900mm diameter bearing piles were installed. The ground conditions were challenging with high groundwater levels and 4m of made ground overlaying peat, sandy gravel and chalk. The geotechnical profile combined with the basement geometry made CSP an ideal technique for the project.

Contiguous bored pile walls

Contiguous bored pile walls are formed by piles that virtually touch each other with theoretical gaps typically being 50-150mm. The soil in the gaps is exposed during excavation, but can be grouted or sealed to form a watertight retaining wall.

To keep the piles vertical, the walls are generally formed on a "hit-and-miss" basis. An initial run of piles is first undertaken, and infill piles are subsequently constructed with existing piles acting as a guide either side. Unlike secant pile walls, guidewalls are not usually required and there is no time constraint on the sequencing of the piles.

Discontinuous bored pile walls

In discontinuous bored pile walls such as "king post" walls, bored piles incorporating vertical structural components (such as I-Beams, steel cages or precast elements) are installed with a greater gap. Shoring in the form of sheets, planks or shotcrete is subsequently placed between the structural elements during successive phases of the excavation process.

There must be no significant flow of water through the ground, and the soil must be able to stand vertically until each phase of shoring is installed. A drainage system on the earth face of the wall can be incorporated to prevent the build-up of water pressure, but this needs to be considered in the construction sequence.

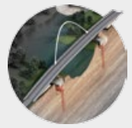
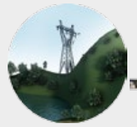
Advantage of the technique

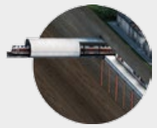
Rapid permanent or temporary earth support system in favourable ground conditions

Summary of techniques








	Jetty	Oil & Gas terminal	Nuclear power plant	Wind turbine	Bridge	Pylon	Tunnel access	Metro station	Underground shopping centre/car park	Building	Quay
Large diameter bored piles DIAMETER From 600mm to 3,600mm DEPTH From 10m to >100m	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Large diameter rock drilling DIAMETER From 600mm to >7,000mm DEPTH From 10m to >100m		✓	✓	✓	✓			✓	✓	✓	✓
Continuous flight auger piles DIAMETER From 300mm to 1,500mm DEPTH Up to 52m		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Rotary displacement piles DIAMETER From 300mm to 800mm DEPTH Up to 32m		✓	✓	✓	✓	✓		✓		✓	✓
Driven piles DIAMETER From 300mm to 5,000mm DIAGONAL From 250mm to 700mm DEPTH >70m	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
Constrained access & low-headroom works DIAMETER From 300mm to >2,800mm DEPTH >75m		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Embedded bored pile retaining walls DIAMETER From 300mm to >2,500mm DEPTH >50m		✓	✓		✓		✓	✓	✓	✓	✓

Soletanche Bachy offers a uniquely broad range of specialist techniques that can be used to form load-bearing foundation elements, or create improvements to the natural load-bearing characteristics of the ground. This publication generally describes load-bearing reinforced concrete and prefabricated piles.

Other techniques excluded from this publication produce foundations that could be classified as piles in certain applications. Many of these are in emerging markets, and employ different materials, equipment and highly specific construction methods. These techniques include: jet-grouted columns, Soil Mixing, rigid inclusions, vibro-columns.

In this publication, retaining structures with limited foundation capacity have also been excluded, although some systems are comprised of piled elements. These techniques include: sheet piling, combi-walls.

More detailed information referencing these related techniques can be provided by Soletanche Bachy on request.

The information provided in this document is for informational purposes only and is not legally binding. The dimensions and capabilities described herein are subject to local ground conditions and plant capabilities within each location or business unit.

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