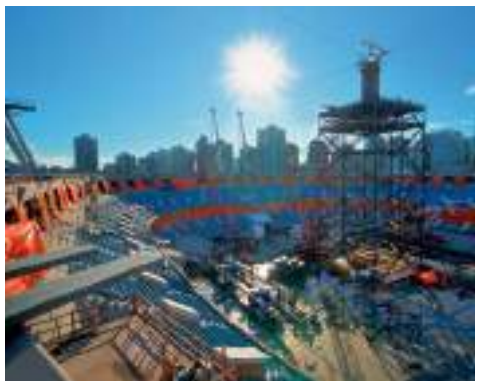
SOLETANCHE FREYSSINET


resonance

The magazine of the SOLETANCHE FREYSSINET group

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EDITORIAL
— BRUNO DUPETY

Chief Executive Officer of Soletanche Freyssinet

> In each of our major entities, we have undertaken a comprehensive overhaul of our safety policy to make progress towards our Zero Accidents objective.

Our Group aspires to set the benchmark in each of its business activities. We will have fully achieved that goal once our safety results are commensurate with our technical and economic performance. Our objective – our sole objective – is Zero Accidents. To help us reach it, we have undertaken a comprehensive overhaul of our safety policy and are setting up action plans in each of our major entities, with clearly identified organisational structures and safety managers, additional tools and resources and, above all, the determination to do what it takes to make progress.

I will be personally involved, as will all our senior managers, in coordinating and tracking these action plans. In each and every one of our subsidiaries, the role of management is crucial if we are to make our improvement objectives a reality.

Our subsidiaries in the English-speaking world have shown us the way forward with their long-standing accident prevention culture, in which safety management is part and parcel of project management. From design through to final execution, in their methods and production processes and in their day-to-day routine, safety is a priority focus. Safety has become second nature.

This model can serve to guide us all. We will build on it, adapting it to the culture and construction methods of each of our countries, supplementing it by adding in the experience and best practices of each of our companies. Soletanche Freyssinet originated in the determination to make resonate the teams and expertise that form the outstanding wealth of this Group. As we embark on the same collective endeavour in accident prevention, our improvement programme will truly come into its own.

Bruno Dupety

Group
— Synergies

ENTIRE GROUP MOBILISES FOR GREATER SAFETY

Two years after the merger that led to the creation of Soletanche Freyssinet, the company is now focusing on improving its safety performance, a commitment illustrated by three senior H&S appointments.

Until recently, Soletanche Freyssinet had focused on forging synergies in technical and support services in order to benefit its business activities. Now it is turning its efforts towards sharing its best practices in safety. The challenge is a sizeable one for a company that, since 2009, can justly claim to be a truly global leader, with 150 subsidiaries operating in some 100 countries, it has a duty to perform to the highest standards in every area of its business. The company's ambition is unequivocal: zero accidents. This goal demands unceasing efforts in the drive for constant improvement. Safety is a central plank of the strategy put in place by the general management *(see the Editorial on page 3)*, which seeks to make the group's safety policy a commercial advantage to complement its technical expertise. A number of fundamental decisions have been taken within each entity as a first step to achieving this aim.

Organisation, training, non-negotiable rules and inspections

Freyssinet, Nuvia and Terre Armée have adopted a regime built on organisation, training, non-negotiable rules and inspections that is now being applied throughout the Soletanche Freyssinet network, underpinned by the

Barry Brown, head of H&S at Freyssinet, Nuvia, Terre Armée.

Vincent Douet, safety manager at Soletanche Bachy.

David Maltman, safety coordinator at Menard.

principles of autonomy and responsibility for all subsidiary companies. The new regime is headed up by Barry Brown, well known in the company for his excellent record on the LRT project in Dubai and now head of H&S for the Freyssinet, Terre Armée and Nuvia group. "In practice, Barry's role will be in the field, where he will spend his time explaining, leading and assisting," says Paul Hease, head of QHSE at Freyssinet. It was in exactly these terms that his new role was presented at the meeting of Freyssinet subsidiary heads held in November 2010 in Brest, France. Exceptionally, this meeting was extended by half a day at the request of Jérôme Stubler, CEO of Freyssinet, Nuvia and Terre Armée, who made a formal statement stressing the importance of this crucial new management approach and launched the safety plan *The safe way is the only way.*

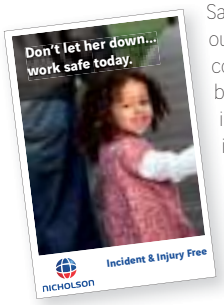
Bringing prevention specialists together

Until now, Soletanche Bachy's safety policy was managed at the subsidiary level, supported by safety action clubs (CAS). Three years ago, a programme was started to help people responsible for prevention to communicate with each other and share their experiences. Again, the company had to build on this and provide a clear signal, which it did in October 2010 with the appointment of Vincent Douet as safety manager. According to him, "what we need is somebody who can get out on sites and really drive the group's safety policy throughout Soletanche Bachy." Vincent Douet's mission will be to "spread the word", develop prevention at the local level, via training if needed, sharing his expertise, providing the necessary tools where they are lacking, publicising and sharing the initiatives of business units that have made the most progress *(see below)*, and so on. His priority for 2011: improve results and oversee the emergence of a shared vision, primarily by organising visits to construction sites "so that [visitors] can see that there is a range of different practices, but that some are good and others are bad."

Sharing solutions between companies

Making sure that best practices are shared through a process of dialogue and open-mindedness would be one way of summing up David Maltman's role at Menard. "He was appointed safety coordinator as of 1 January 2011," says Marc Lacazedieu, Menard's CEO. "He started his working life at Bachy UK and we look forward to benefiting from the pragmatic approach to safety that has been so successful in English-speaking countries." In the short term, his job will be to audit H&S policies in Menard's five regions, which are not all to the same standard. "The idea is not to impose a vision from top-down, but simply to see where we stand, take up the best ideas and to encourage more sharing of problems and solutions between our various entities," adds Marc Lacazedieu.

Progress somewhere, progress everywhere



Safety is important to our people in every country, as witnessed by the array of safety initiatives and innovations. Many good ideas are being shared across our network. A prime example, and one we can all learn from, is *Incident and Injury Free*, a campaign developed by Nicholson in 2009. Jason Timmon, head of safety at Nicholson, takes up the story: "We've always had a good safety record, but we decided that we didn't want to be a leader simply in geotechnical methods and construction, we wanted to be a leader in safety as well." The campaign didn't set out to address any risk in particular, nor did it set any quantified targets; it simply encouraged its staff to make safety their number one priority. The campaign rollout was backed by a feedback programme, awareness-raising and training. The results speak for themselves: a record period of over 500,000 accident-free working hours and no working days lost because of injury between January and November 2010, a 37% cut in the number of injuries requiring medical treatment during the same period, and a 45% increase in the number of near misses reported.

Anniversary

RECo Canada hits 40!

The end of 2010 marked the fortieth birthday of the Reinforced Earth Company Ltd Canada (RECo Canada), Terre Armée Internationale's oldest non-French subsidiary. Founded in Montreal in April 1970 – with original share capital of a single 20 Canadian dollar bank note! – the company currently employs 19 staff and is a success story whose C$13.5 million revenue comes from projects such as Port Mann, Vancouver, British Colombia *(see page 22)*, where it will supply 18,000 m² of structures over a four-year period. The anniversary celebrations were attended by Bruno Dupety, Philippe Héry, head of TAI Corporate, and Roger Bloomfield, head of TAI North America. Peter Wu, head of RECo Canada, praised the efforts of his staff and saluted the trust in the company shown by its clients. Since 1970, RECo Canada has completed over 800 projects comprising in excess of 870,000 m² of Reinforced Earth® walls and TechSpan® arches from Vancouver to Newfoundland and Labrador. In 2005, RECo Canada extended its geographical spread to include the islands of the Caribbean.

Opening

The Térénez Bridge: a triumphant technical and aesthetic achievement

After four years of works, the new Térénez Bridge in Finistère, France was opened on 16 April 2011. A large crowd gathered to witness the event and the celebrations continued until the bridge opened to traffic late on Sunday afternoon. Universally praised for its signature 100 m high lambda-shaped towers and curved deck (at 285 m, a world record length for a curved span), the bridge, designed by architect Charles Lavigne and engineer Michel Virlogeux, in fact owes these characteristics to the requirements of site context and user safety. Meeting the challenges needed to see it through to completion represents a triumph for the skills and combined expertise of VINCI Construction France companies, including Freyssinet (cable stays and prestressing) and Terre Armée (abutments).

Event

Freyssinet Mexico and Cimesa repair a key Mexican motorway structure in just 90 days

On 31 August 2010, at the border between the states of Jalisco and Nayarit on the Mexican Pacific coast, the collapse of the carriageway carrying south-north traffic over the river on the Puerto Vallarta-Guadalajara freeway meant that local authorities were forced to divert all traffic onto the two-lane north-south carriageway, about 200 m downstream. This emergency measure could not stay in place for long owing to the amount of traffic on this route, so the transport ministry (SCT) gave Freyssinet Mexico just three months to repair the structure. "There was no way to replace the bridge identically, with a river pier and a concrete deck, in such a short timeframe," explains Luís Rojas Nieto, CEO of Freyssinet Mexico. "We launched a competition for ideas, with the consultant engineers at Euro-Estudios and Cimesa working together to meet the delivery deadline, scheduled for 5 December." It quickly became clear that the solution was to replace the two 30.6 m concrete spans with a single 200 t steel span resting on twin piers that would have to be built on both banks, and that would then be pushed and craned into position; there wasn't enough time to use a launching gantry. Starting in October, Cimesa

drove the foundation piles for the new piers, working on dry land. Freyssinet Mexico spent November working on the carriageway deck, dividing their efforts between assembly, putting it into position and treating it with Foreva® GP Zinc anti-corrosion treatment. Teams from both companies worked 24/7 so that the deadline, and the challenge, would be met – an effort warmly acknowledged by Jorge Moreno, head of Freyssinet's Spanish and Latin American operations. The new carriageway was opened to traffic by Mexico's transport minister, Maestro Juan F. Molinar Horcasitas, on 8 December 2010.

Award

On 23 January 2010, Bachy Soletanche Vietnam was honoured with the 2010 Golden Dragon Award for performance and service excellence. The awards recognise international firms that make significant contributions to Vietnam's economy. Eighty companies were eligible, including Toyota, Honda, Samsung, Ford, Mercedes-Benz and Coca-Cola.

Synergies

Nicholson-Menard partnership in the USA

Across the Atlantic, the period following the creation of Soletanche Freyssinet was, for a variety of reasons, the perfect time for strengthening ties and collaboration between Menard (whose US arm was set up in 2002) and the Nicholson Construction Company (founded during the 1950s). First was their geographical proximity, with only 2 kilometres separating the respective head offices in Pittsburgh, Pennsylvania. Then there was the human factor, as many Menard staff were former Nicholson people. Almost inevitably, once the right occasion presented itself – the Essington market rehabilitation project, then the Penn Park university sports complex *(see page 14)* – the two companies combined their foundation and ground engineering expertise to offer their clients the best solution to their needs. Determined to capitalise on the excellent fit of their businesses to the fullest possible extent, and to expand their presence in the US market, the two companies decided to formalise their ties via a partnership agreement that came into force on 1 January 2011.

From now on, all ground engineering activities, including vibro compaction, previously offered only by Nicholson, will be performed under the Menard brand. This applies across the entire Nicholson network (Boston, Massachusetts; New York; Kalamazoo, Michigan; Salt Lake City, Utah; Austin, Texas; Kansas City, Missouri; and Miami, Florida), and the possibility of combined offers will be examined systematically. It's a win-win situation for both sides: for Nicholson there is the chance to make combined offers, a clear advantage over its single-activity competitors, and for Menard there is the geographical spread since, aside from Pittsburgh, it was formerly present only in Cleveland, Ohio and New Orleans, Louisiana. But neither side intends to leave it at that, "because we also need to improve our profile in the marketplace," explain Frédéric Massé, vice-president of engineering at Menard, and Fred Tarquinio, engineering manager at Nicholson. "So we're already at work, as much in terms of engineering as in design and marketing, trying to create a more integrated identity via our website, brochures, technical submissions and so on."

Training

Safety on the programme at Freyssinet

Philippe Zanker, head of Freyssinet France, has overseen the inclusion of a specific safety module in the four-month training programme run at the Eugène Freyssinet training centre (CFEF). The programme was followed by 123 trainees from Freyssinet France in 2011. "We took a close look at every element of daily working, including all the tools and equipment," explains centre manager Alain Autissier, "the idea being to lead trainees to understand that they are important elements in managing on-site risks, as well as to optimise their comfort at work." For every trainee, irrespective of their grade, critical analysis of specific tasks acts as an incentive to improve the way that they organise their own work, "and the opportunity to prove the truth of the old saying that good preparation is half the battle," concludes Alain Autissier.

New contracts

Hong Kong — Soletanche Bachy
As part of the Central Wan Chai Bypass project (an expressway traversing Hong Kong island from west to east), in early 2011 Bachy Soletanche Group Ltd, as subcontractor to China State Construction Engineering, was awarded a contract for the construction of 37,000 m^2 of diaphragm walls and barrettes. The grabs were located on temporary offshore islands when working in proximity to the marina.

Turkmenistan — Menard
In the South Yoloten Gas Field, one of the world's largest, the EPC contractor (Petrofac) awarded Menard a ground consolidation contract for the 1,150,000 m^2 site planned for a new gas treatment plant. The work took approximately three months to complete.

France — Soletanche Bachy
Three years after completing, as subcontractor to GTB Construction, the deep foundations for Cargill's Montoir de Bretagne biofuel plant in Loire-Atlantique, France, Soletanche Bachy Pieux was awarded the deep foundations contract, also by GTB, for the new extension to the plant. This is a very challenging project as the drilling rig has to manœuvre between silos and beneath the site's conveyor belts to gain access to the area earmarked for the construction of seven new structures.

France — Soletanche Bachy
Following the cessation of production at the underground propane gas storage centre in Gargenville, France, Soletanche Bachy's North & West agency had its tender accepted for the design and placement of infilling at the site. The project, on behalf of Geostock, includes drilling and filling in. The total volume of mortar-filling to be produced is estimated to be approximately 21,000 m^3.

Vietnam — Freyssinet
In late 2010, contracting authority UTMD2 awarded Freyssinet Vietnam the contract to strengthen Saigon Bridge, located to the northeast of Ho Chi Minh City. The turnkey contract covers design (supervised by the Technical Department) and construction of reinforcement to the concrete slabs of the primary structure spans, replacement of the suspension system for the central metal span, consolidation of the foundations for one of the piers and renewal of the road surface (watertightness, asphalt and roadway joints).

SUSTAINABLE DEVELOPMENT

Sustainability
Our policy in action

Soletanche Freyssinet's sustainable development policy is underpinned by our group's determination to be constantly creative and explore new ways of providing clients with added value in the course of our operations.

By virtue of their activities, companies in the Soletanche Freyssinet group use innovative procedures that ally technical performance with competitiveness – and they love a challenge. They have all, in their own specialist fields, developed solutions that consume fewer raw materials and reduce the environmental impact compared to traditional technologies.
We therefore adopted carbon footprint audits as a way of testing emissions produced by our projects as early as 2006. Soletanche Bachy has now developed Prism, an environmental footprint measuring tool *see opposite)*. Says Marine Lasne, head of sustainability at Soletanche Freyssinet, "Prism is one of the first concrete expressions of the group's sustainability policy set out in 2010. Our policy takes the form of a commitment to manage environmental risks and cut the environmental and social impacts of our activities, to assist clients with their projects, and to build on our record as responsible and active citizens." Since its activities place it at the centre of many of the problems of sustainable development, Soletanche Freyssinet has decided to turn this challenge to its competitive advantage. "Our ambition extends way beyond just limiting the impact our activities have on the environment," continues Marine Lasne. "It's something that will lead us to re-imagine our core specialities, driven by the constant desire to show proof of creativity and to explore new ways of providing our clients with added value in the course of our operations."
Driven by this determination, the group will be leveraging its core expertise and the inherently innovative nature of its approach to develop new offers and pioneering solutions with the focus on sustainability: geothermal, wind power, protection against natural and industrial risks, repair solutions (Foreva®), and new foundation technologies (soil mixing, rotary displacement piles, etc.).

Prism
Measuring the environmental impact of variables

Soletanche Bachy has developed a new tool as part of its overall sustainability policy, and in particular its efforts to drive down the environmental impact of its activities. Called "Prism", it uses life cycle assessment (LCA) to produce a quantified audit of an operation's environmental footprint. Group companies will be using it in the future either at the request of clients or as part of tenders, and it will enable them to assess the environmental impacts of various techniques and the benefits of the alternatives proposed.

Prism

Soletanche Freyssinet 2010 Business Report
Financial results and headline projects along with updates on further synergies, the innovation policy and sustainability: everything you need to know about our 2010 results is summarised in the Business Report, which was published in early May. Available via email on request: info@soletanchefreyssinet.com

Innovation

e.2Log: a track & trace tool for services

Essor (Nuvia) supplies specialist logistic services to the nuclear industry, an activity that inevitably generates a considerable volume of information that has to be logged, checked and analysed. Advitam* has developed a revolutionary piece of real-time service tracking software for Essor, known as e.2Log. It is extremely simple to use: for every task required, the operative scans the barcode attached to the piece of equipment and is then instantly presented with a log of all interventions previously performed, as well as any other information needed to complete the task under the best possible conditions (the feedback). Once the task is completed, tracking data are immediately transferred for centralised storage and archiving, adding more feedback. The software was tested at the power station in Dampierre en Burly, Loiret, France, in late 2010. It was enthusiastically welcomed by clients and operatives alike, and will be deployed during 2011 at all sites monitored by Essor.

** A Soletanche Freyssinet subsidiary, Advitam specialises in the inspection and monitoring of structures.*

New agencies

On 1 January 2011, Menard and Soletanche Bachy joined forces to create new shared agencies in Warsaw and Preston, UK. The new Polish agency is based on existing Soletanche Bachy and Menard companies (Soletanche Polska and Menard Polska), and the UK agency is the result of merging Menard France's resources with those of Vibro Project Ltd (Soletanche Bachy). These two 50-50 joint ventures will offer clients in their respective countries surveying and technical expertise covering the full range of ground improvement works.

Early January 2011, Gerry Crawford, head of Vibro Project Ltd *(left)*, and Cyril Plomteux, France Europe manager at Menard, shake hands to celebrate the creation of the UK-based Vibro Menard agency.

New contracts

Lebanon — Freyssinet
Consulted in late 2010 about a problem with cracks appearing in silos (structures 68 m high for a diameter of 15 m), the Major Projects division at Freyssinet was instructed by the operator of the Chekka cement works near Tripoli to undertake strengthening work on the four structures. The decision was taken to use external prestressing techniques, with sheathed tendon cables fitted inside sheaths that were then grout-injected.

Vietnam — Menard
Menard was awarded two contracts in southern Vietnam. The first, for the Gemalink Container Terminal, consists in provisionally stabilising river banks for the future terminal, using the Menard Vacuum® process on an area of around 35,000 m^2, a similar task to the 2010 job Menard completed a kilometre away for the Cai Mep International Terminal project. The second contract, SOFE Quay Wall Stabilisation, covers the use of the soil mixing technique to consolidate the ground behind the future jetty wall, a project where Menard has previously carried out CMC consolidation work.

USA — Soletanche Bachy
Nicholson Construction Company, in a joint venture with EE Cruz, was awarded the contract to construct foundations and basement levels for the first phase of Columbia University's Manhattanville project, located on a brownfield site in West Harlem. The main features of the contract include creating 14,300 m^2 of diaphragm walls between 129th and 130th streets.

Saudi Arabia – Menard
At Ras Az Zawr, to the north of Jubail on the Persian Gulf, Menard is carrying out dynamic compaction and replacement works as well as creating vertical drains with a surcharge prior to the construction of a 240,000 m^2 desalination plant and a 150,000 m^2 power station.

France — Nuvia
Having previously been awarded the anti-seismic bearings contract for the Jules Horowitz reactor at Cadarache, NTS (Nuvia) also won the design-build contract for 500 anti-seismic bearings for Iter, the international thermonuclear reactor experimental project being built on the same site.

India — Soletanche Bachy
In late 2010, the National Hydroelectric Power Corporation asked the Grands Projets division at Soletanche Bachy to create a watertight cut-off wall on the Subansiri dam, a concrete gravity dam currently under construction in Assam state, located between Bangladesh and Burma. The 800 mm thick and 50 m deep wall will be created using a Hydrofraise rig.

Projects

FREYSSINET
— The Golden Horn and Russky Island bridges, Vladivostok/Russia

Two giant bridges open up the far east of Russia

Russia was the last nation to join APEC (Asia Pacific Economic Cooperation), the intergovernmental forum created to promote trade among countries of the Pacific Rim. In 2012 the country will be hosting the APEC annual gathering. Vladivostok, the capital of Russia's far east, is seven time zones (9,302 km) from Moscow but less than an hour by plane to Japan and close to China and South Korea, and the event is viewed as a great chance to increase development throughout the far-flung east of the country. Eager to accord its guests appropriate levels of hospitality, the Russian government has commissioned around 40 prestige projects and refurbishments, the most high-profile being the airport extension, the construction of a 50 km motorway linking the city with the airport, an opera house, and two giant bridges: Golden Horn and Russky Island. Built by different international firms, and very different in terms of the shape of their towers, both structures are equipped with Freyssinet stay cables.

The world's longest cable-stayed span

Spanning 737 m, enough to class it among the world's top 10 cable-stayed bridges, the Golden Horn Bridge is located within the harbour of Vladivostok, straddling a stretch of water that divides the northern and southern sides of the city. The second bridge will connect the city's southern tip to the forum venue on Russky Island. It will beat the current world record holder, China's Sutong Bridge (1,088 m), with a span of 1,104 m for a total length of 1,872 m.

"We are highly encouraged that Russian contracting authorities and designers want to benefit from the enhanced bridge durability that Freyssinet's parallel strand stays (PSS) offer in comparison to the parallel wire systems (PWS) fitted to the two previous holders of the record," explains Jean-Daniel Lebon, Head of Business Unit 1 at the Major Projects division. More generally, the two projects in Vladivostok have provided an excellent showcase for the company's expertise and experience in cable staying and large-span bridges in difficult environments (ice, cold, high winds, etc.).

In late 2010, as the civil engineering teams continued to work on constructing the towers for the bridges (reaching 226 m high for the Golden Horn Bridge and 321 m for the Russky Island Bridge), as well as piers for the viaducts and approach spans, the stays were already under construction in Freyssinet's factories. All the hardware, some 450 containers in total, had to be dispatched before work could begin on fitting the stays to the bridges, a task scheduled for spring and late autumn 2011.

Participants
Contracting authorities: City of Vladivostok, Primorsky Kria (Golden Horn Bridge) and the Russian Federation Ministry of Transport (Russky Island Bridge)
Project management: Federal Road Agency of the Ministry of Transport of the Russian Federation (FGU DSD Vladivostok)
Main contractor: TMK (Golden Horn Bridge), USK Most with an SK Most-Mostovik subcontracted consortium (Russky Island Bridge)
Specialist contractor: Freyssinet Major Projects-Freyssinet Russia joint venture

01

01 - 02 - 03 To reduce wind drag and deal with vibration issues inherent in major bridges, compact stays are used on the Golden Horn Bridge (illustrations 01 and 02) and supercompact stays on the Russky Island Bridge (illustration 03). They are all fitted with internal radial dampers (IRD) and pendular external dampers (PED) supplied by Freyssinet.

02

03

Q&A

Pierre Mellier
Director of Structures, Central & Eastern Europe, at Freyssinet

How long has Freyssinet had a presence in Russia, and how is it structured?
Freyssinet began its activities in Russia in the late 1990s on an export-only basis. We then opened a Moscow office which made it possible to work on projects in Russia, Belarus and Kazakhstan. For the past few years, Freyssinet Russia has operated as an independent subsidiary based in Moscow.

Key figures

Golden Horn Bridge
Number of stays: 192
Length of stays: 97 to 390 m
Total strand length: 1,613,313 m
Russky Island Bridge
Number of stays: 168
Length of stays: 135 to 580 m
Total strand length: 2,947,936 m

01

01 After the preliminary earthworks, the team from Menard Spain SA took five weeks to consolidate an area of approximately 25,000 m².
02 Further excavations were made, as needed, to a depth of 0.80 to 1 m.
03 The 19 t pounder was released from a height of 23 m, creating applied energy of 450 tm/m².

MENARD

— Levant high-speed rail link, Almansa-La Encina section (package 3)/Spain

A successful turnkey dynamic compacting solution

Ever since it started the activity in the early 2000s, and more particularly since it set up its local subsidiary in 2009, Menard has been tightly focused on developing dynamic compacting in Spain. "Most ground improvement techniques are well known and are often already specified and scheduled when a project is launched," explains Teresa Pérez Rodríguez, head of Menard Spain SA. "But dynamic compacting is different, and clients have to call on specialist consultants and contractors to get it done – unless they come to us! We're the only ones to offer both surveys and the work itself." Of the three dynamic compacting projects completed during 2010, the one the company is most proud of was carried out not far from Almansa, Murcia, along the route of the future Levant high-speed rail link. The main contractor, UTE La Encina, was unable to determine the type of treatment to use on an area of around 25,000 m² that lay along the route and had been identified during an exploratory drilling test as being liable to subsidence. It therefore called in Menard Spain SA for a diagnosis. Analysis revealed the presence of a 5- to 6 m-thick layer of silt sand soil at a depth between 3 and 4 m. Menard Spain SA felt that the best solution would be dynamic compacting. The idea was approved by the technical project manager and consultant engineers and met with the approval of the client, which nonetheless chose to consult other companies about carrying out the work. "Our tender was not the cheapest," admits Teresa Pérez Rodríguez, "but we were the only ones to offer a guaranteed result for a lump sum, and I've no doubt that that was the decisive factor." The operation was carried out over a five-week period and was closely monitored by an engineer from the company – to the satisfaction of all. With the work completed, the subsidiary was happy to be asked by the client (Adif) to draw up a standard set of guidelines to follow in the event that further ground problems were to occur.

02

03

Participants
Client: Administrador de infraestructuras ferroviarias (Adif)
Main contractor: UTE La Encina (Rover Alcisa-Construred)
Specialist contractor (design and execution of the ground improvement package): Menard Spain SA

SOLETANCHE BACHY

— Construction monitoring for the Shard of Glass tower, London/UK

A sensitive site under high surveillance

The Shard of Glass *(see box)* is a strikingly modern prestige project that has transformed London's skyline. But well before its completion it had already brought about profound changes to its immediate surroundings, not far from Tower Bridge. The new building stands on the former Southwark Tower site, a high-rise office complex built in the 1970s. Its foundations lie very close to London Bridge Station, London's fourth busiest railway station, and immediately above London Bridge underground station, one of the world's oldest underground railway stations serving both the Jubilee and Northern lines. Variations in ground pressure caused by the demolition of the former tower, the removal of demolition waste, construction of three new basement levels for the new tower, and the ground loadings created by the new 72-storey structure meant that Mace, the main contractor, knew that monitoring instrumentation would be needed even before demolition started. The aim was to make certain that neighbouring surface and underground structures remained unaffected by the works, and to ensure that the Network Rail and London Underground networks could continue to operate normally.

"SolData was hired back in February 2007," explains Christophe Bourlart, CEO of SolData Ltd, "and our first efforts centred on the underground rail foundations, which comprise a network of 19th century vaulted brick arches that house a theatre, a covered market and the London Dungeon. The escalators, tracks, underground passageways and the market were all fitted with instruments. Detailed work to determine the exact settlement footprint meant that the job was extended to include a number of office buildings, the Network Rail viaduct arches and the façades of Guy's Hospital. Once construction work got under way on the basement infrastructure in early 2009, our monitors were used to predict the structural behaviour as soon as work on the superstructure began."

Monitoring the entire neighbourhood

The instrumentation comprised 20 fully robotic networked high-precision stations (Cyclops) used to monitor absolute movement in three dimensions. These were used in combination with over 250 standard instruments monitoring discrete movements and 19 inclinometers used on the diaphragm wall of the basement levels. In addition to the automatic monitoring systems employed, a rigorous protocol for the use of traditional surveying methods was put in place.

All data from automated instruments were collected via wireless link and processed using SolData's Geoscope software; results from the manual surveys were also incorporated. All concerned parties were able to monitor data remotely via the Internet and to make more detailed analysis using computers running Geoscope. Alarms were set at predetermined thresholds so that key personnel as well as the contracting authority and client could be automatically informed and actions taken rapidly, were these prove to be necessary.

Aiming to beat the European record

At 310 m high, the Shard of Glass aims to be Europe's highest tower on completion, scheduled for 2012. Designed by architect Renzo Piano, this will also be one of Europe's most unusual buildings: a triangular tower whose glass cladding changes colour according to the time of day and the weather. A mixed-use development with offices, apartments, hotel and retail space, the Shard of Glass will have a total of 72 storeys.

Participants
Client: Sellar group
Main contractor: Mace
Specialist contractor: SolData

At the basement level, the foundations for the tower under construction are very close to the highly sensitive underground rail system and London Bridge Station.

01

MENARD/SOLETANCHE BACHY/TERRE ARMÉE

— Penn Park university sports complex, Philadelphia/USA

Working together to propose a winning alternative

In 2008, as part of the Essington Avenue project in Philadelphia, the Nicholson Construction Company turned to DGI Menard for its ground improvement expertise. A few months later came the Penn Park project, again in Philadelphia. This was the future sports complex for the University of Pennsylvania, which this time presented a chance for DGI Menard to call on expertise from around the group – in this case Nicholson and the Reinforced Earth Company (RECo) – and to make best use of them. Frédéric Massé, vice-president of engineering at DGI Menard, takes up the tale: "In late 2009, we were contacted about this project's ground improvement package by a number of main contractors. Aside from the service that they wanted – the creation of vibro concrete columns – we were able to suggest different approaches to creating foundations and retaining walls, areas where Nicholson and RECo have considerable expertise. This meant that we were able to put in a bid that was far more competitive."

The project was to occupy a site of around 100,000 m^2 separated from the main campus by railway tracks to the west, and delineated by a freeway and the River Schuylkill to the east. The site included running tracks, baseball and American football fields, tennis courts, and all their associated requirements (locker rooms, etc.), separated from each other by grassy embankments forming terraced seating in places and used as pedestrian routes reached via footbridges over the railway tracks. "The original brief was for concrete retaining walls and terraces to be poured on site, as well as a large number of standard piles for the foundations for the walkway piers, including the area close to the railway, where access is difficult," Frédéric Massé explains.

In each of these areas the alternative solutions proposed by RECo, Nicholson and DGI Menard were the clear winners: in financial terms, with retaining walls and terraces in Reinforced Earth® constructed with conventional facings, as well as in terms of feasibility for the walkway foundation piers, using Nicholson's micropiles. As alternatives to vibro concrete columns (ground improvement) and piers (foundations), the solutions proposed were conventional CMCs beneath the earth banks and retaining walls, with reinforced CMCs for the pier foundations.

"Taken together," says Frédéric Massé, "the bid that we put together for Turner, the main contractor, helped the client to save several million dollars." With the contract signed in April 2010, work commenced in June, finishing in November the same year with the completion of the Reinforced Earth® structures.

Participants

Client: University of Pennsylvania
Project management and architect: Michael Van Valkenburgh Associates, Inc.
Main contractor: Turner Construction
Specialist contractors: DGI Menard, Nicholson Construction Company (Soletanche Bachy), Reinforced Earth Company (Terre Armée)

02

03

01 - 02 - 03 Combining the three companies' specialist techniques with a revised design meant that their bid was by far the most competitive.

FREYSSINET

— BC Place Stadium, Vancouver/Canada

A 20,000 t cable-stayed crown

No sooner had the 2010 Winter Olympics drawn to a close than a huge worksite got under way at BC Place, the 60,000-seat stadium in Vancouver, to replace the roof damaged by a storm in 2007. "The client chose to replace the old dome, a membrane supported by air pressure, with a retractable roof supported by a cable structure anchored to 36 peripheral masts with a height of 50 m. This will completely transform the appearance of the stadium. This is an outsize project for us, the kind of project an engineer only sees once in a lifetime," says the Freyssinet Canada operations manager, Franck Chavent.

72 H2000 stay cables

Freyssinet is a major provider of cable-stayed structures and has a substantial international track record in stadium construction *(see* Resonance *No. 2)*. Freyssinet won the supply and installation contract for the BC Place structure in 2009. The contract covers 700 locked coil ropes of 18 to 125 mm diameter forming the net (the two sets of radial cables linking the masts with the centre node), the tension ring around the circumference that stabilises the structure and 72 H2000-type backstay cables. Starting in June 2010, nearly 200 employees worked on the site to install the structure. The operation was complicated – the roof, which weighs 20,000 t (two and a half times the weight of the Eiffel Tower), was placed over the existing structure like a crown, with the tension and compression rings (one of each) around the circumference absorbing all horizontal forces transmitted by the masts.

Painstaking installation requiring rigour and methodology

A method had to be devised to rigorously phase the installation work so as to manage the forces induced in each element. To start with, each mast was placed by an 850 t mobile crane and supported by temporary cables. After the first 10 masts were installed, lifting jacks gradually placed the first set of cables between the masts and the centre node, which was supported by a 78 m telescopic steel tower. To achieve balance, the work was carried out radius by radius between diametrically opposite masts separated by a distance of more than 200 m. Only after the stay cables had been installed were the temporary mast support cables removed and the structure tensioned in multiple, complex jacking operations.

The new BC Place Stadium is scheduled for completion in mid-2011 and is to host the first game of the Canadian football championship in May. Franck Chavent is looking forward to the event: "The stadium will be the city's new emblem. It will be seen on all the postcards," he says.

Participants
Client: PayCo (BC Pavilion Corporation)
Project manager: Geiger Engineers/Schlaich Bergermann and Partner LP
Main contractor: PCL Constructors Westcoast Inc. Canam.
Specialist contractor: Freyssinet Canada Ltée

01

01 In the construction phase, the centre node is supported by a 78 m high telescopic support tower.
02 - 03 Each support mast is 50 m high. The forces are offset by H2000-type backstays equipped with cast anchorages.

02

03

SOLETANCHE BACHY

— Cardinet car park, Paris/France

Open excavation to build 609 underground parking spaces

Breaking with a decade-long trend, the City of Paris issued a call for tenders for the concession and construction of a new underground car park in 2007. The 30-year concession was awarded to SAEMES and the construction to Soletanche Bachy, as main contractor, together with Cosson. The facility is being built in an area, next to the Martin Luther King garden in the Rue Cardinet, where a preliminary study had identified a shortfall of about 1,000 spaces. "This is a six-level, 609 vehicle capacity car park with a conventional helical ramp and entrance and exit rotunda design," says project director Guillaume Piar. "But it does have two features that stand out: it will be one of the first Paris car parks equipped with sprinklers for fire protection and it will have a ceiling height of 2.30 m to accommodate small utility vehicles."

Soletanche Bachy began work at the site in March 2010. The project started with the excavation of the 170 m long, 15 m wide, 22 m deep box. Work on the diaphragm walls got under way in April, following construction of the guide walls. The 0.60 m-thick diaphragm wall is anchored in a marl and gravel horizon at a depth of 39 m, i.e. 17 m below the bottom of the excavation, to avoid an anomaly zone of gypsum dissolution voids at 32 to 35 m. Two machines, a KS hydraulic grab and a Hydrofraise HC 03 (the most compact model), were used in two shifts between 6.30 a.m. and 10.30 p.m. to build the diaphragm wall in adjacent, approximately 9.60 m-wide panels connected by a waterstop to prevent water ingress through the joint (the water table lies at a depth of about 10 m).

When this stage was completed in June, construction of the rotundas and mass earthworks got under way. This work was carried out in open excavation to avoid worker exposure to any fumes from polluted soils and maintain a good pace – at the height of activity, about 100 truck rotations were removing spoil every day.

A new kind of prop

As the earth moving proceeded, props were installed in rows of 40 units to support the diaphragm wall against the earth and water pressure. "Two of the three rows use 'adjustable head' props, which we are testing; we expect them to be very effective in providing safety and to speed up prop removal as the inside floors of the car park are installed," says Guillaume Piar.

Following construction of the inverted-arch foundation slab, the project proceeded, in January, to the installation of the prestressed hollow core slabs and vertical structure at a very rapid pace – much faster than the planned 3.5 weeks per level. Installation of the prefabricated roof beams began in early April and the structural work is scheduled for completion at the end of July.

Participants

Concession granting authority:
Paris City Hall (Roads Department)
Concession company, programme manager: SAEMES (Société anonyme d'économie mixte d'exploitation du stationnement de la Ville de Paris)
Architect: AG Concept architecture
Execution project manager: Cabinet 4C
Civil works package: Soletanche Bachy (foundations, retaining walls, interior concrete structure, roof slab, waterproofing), Cosson (earth moving, remediation)

Key figures

Diaphragm wall: 15,000 m^2
Earth moving: 60,000 m^3
Reinforced or prestressed concrete slabs: 15,000 m^2
Contract value: €16 million (excl. VAT)

01

01 The new 15 m wide, 170 m long car park will be able to accommodate more than 600 vehicles on six levels.
02 120 props in three rows were installed as the earthworks progressed to support the diaphragm walls.
03 A new type of prop with "adjustable head" was tested on the project. It is designed to enhance safety and speed up the prop removal phase.

02

03

Two of the three rows use 'adjustable head' props, which we are testing. They are expected to enhance safety and speed up prop removal.
Guillaume Piar

01

01 Decommissioning of the glove boxes inside an airlock to ensure containment of all radioactive elements.
02 Once dismantled, the constituents are placed in a triple welded vinyl containment and then stored in drums.

02

NUVIA

— Decommissioning in Cadarache/France

Three contracts consolidate activity

At the French Alternative Energies and Atomic Energy Commission (CEA) site in Cadarache in southern France, Areva was responsible for operating the plutonium technology shop (ATPu) and the chemical purification laboratory (LPC), where fuel for the fast neutron and pressurised water reactors was fabricated from the 1960s until 2003, when they were shut down. Their rows of glove boxes – large airtight Plexiglass or Lexan boxes – are now being dismantled. The preliminary phase of the decommissioning work consisted in extracting all residual plutonium and uranium dust deposited over the 40-year period. The glove boxes are then disassembled and their constituents cut into pieces that can be placed as waste in a containment consisting of a triple welded vinyl envelope and stored in 100 litre drums.

"From the start of the disassembly operation, the glove boxes no longer serve as the primary contamination barrier," says Rafael Teruel, regional director of Salvarem (Nuvia). "The companies are therefore working in an 'alpha plutonium' environment containing little penetrating radiation but extremely toxic particles, in which ventilated airlocks and special protective equipment and methods must be used."

Teams boosted to cope with peak activity

Based on its experience with many similar sites in France and the UK, Nuvia has the expertise to perform this type of work. Its subsidiary Salvarem first won the contract to dismantle the ATPu glove boxes and then a second contract covering the LPC. In early 2010, Salvarem won a further contract to dismantle the overhead tunnels connecting the rows of glove boxes with each other.

The operations now under way will continue until mid-2013, "but other projects are currently in the design or preparatory phase, suggesting that our activity at the site is likely to continue in the future," says Rafael Teruel, "and for that reason we have set up an agency in Cadarache."

Stakeholders

Client: Areva
Project manager: Areva
Specialist contractor: Salvarem (Nuvia)

SOLETANCHE BACHY

— Jetty in Buenos Aires, Argentina

A Danish quay with diaphragm walls

The port of Buenos Aires, Argentina has to upgrade its infrastructure in the face of the increasing tonnage and length of ships that need to use it. In the northern port, a dock dating back to the 1920s cannot be used by vessels over 300 m long*. Terminales Rio de la Plata (TRP), the port concession company, hired Soletanche Bachy Argentina as main contractor for its modification project. Explains project director Michel Yon: "The landside extremity ends in a wedge shape, and our work will be to remove a section of this point to make it rectangular. To achieve this we will have to demolish the previous structure, then build a new 127 m-long diaphragm wall for the jetty, then construct a Danish quay within the area reclaimed from the sea (approximately 3,700 m^2)."

Wall, beam, anchors

The first phase got under way in August 2010. It consisted of creating the future jetty wall: a 1 m-thick diaphragm wall to a depth of 21 m with 72 retaining anchors and topped by a crown beam. These tasks were completed by October and mid-November respectively, then work began on putting the anchors in place and Norgav, the local subcontractor, began using explosives to demolish the old jetty, with debris being removed by boat. Earth-moving and dredging operations also got under way at the same time.

At the northern edge of the site, casings for the 82 piles (800 to 1,200 mm in diameter) were vibration-driven to a depth of 21 m prior to the concrete piles being driven down from a barge to a depth of 31 m. "The presence on the riverbed of material from another jetty that had collapsed in the past did nothing to aid our operations," Michel Yon observes.

A barge was employed from which to drive the 82 piles that will support the outer edge of the Danish quay.

More generally, the relatively small scale of the operation means that each phase is a prototype and that it is very difficult to make up any delays that might arise. The site is due to be handed over during the summer of 2011, once the Danish quay, the final element, is completed.

** By way of comparison, the largest passenger vessel currently afloat is the 345 m* Queen Mary II.

Participants

Client: Terminales Rio de la Plata (TRP), a DP World subsidiary
Project management: Larrague y Asociados
Main contractor: Soletanche Bachy Argentina
Specialist contractor: Norgav (demolition, dredging, earth moving)

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01 The project's 33,000 m² retaining structures designed and supplied by Reinforced Earth Company Ltd (Canada) represent the largest contract ever awarded to the company.
02 - 03 Twin 75 m towers and 288 Freyssinet stay cables will support the 10 vehicle lanes on the new Port Mann Bridge.

TERRE ARMÉE/FREYSSINET

— Port Mann Highway 1, Vancouver/Canada

Our group at the heart of a major PPP project

After the Golden Ears Bridge (*see issue No. 1 of* Resonance) and the BC Place stadium *(see page 16)*, the group is working on another Vancouver-based project. This time it concerns a strategically important piece of infrastructure: the trans-Canadian Highway 1 as it nears the city, and a critical point along its route, the Port Mann Bridge over the Fraser River. This section of the motorway linking Vancouver with Lower Mainland – the smallest and most heavily populated region of British Columbia – and the five-lane bowstring bridge built in the 1960s no longer meet the needs of today's traffic. A major refurbishment programme was launched by the federal government. Spread over a four-year period, the public-private partnership project involves modernising interchanges and the motorway connecting Vancouver with Langley over a distance of approximately 40 km, as well as the construction of a new bridge to replace the existing structure.

A 33,000 m² project for RECo Canada

The motorway element of the project is worth approximately C$2.6 billion, and includes a great many supporting structures: walls (from 5 to 12 m high) and abutments. Up against competing tenders based on conventional solutions using diaphragm walls poured in situ and ground reinforcement, the bid from the Reinforced Earth Company Ltd (Canada) was finally chosen thanks to the advantages that Reinforced Earth® offers when used in areas prone to seismic activity. RECo Canada started looking at the project in mid-2009, and eight months later was awarded the works package by Keiwit-Flatiron General Partnership, the consortium responsible for the civil works. This was the largest project and the most valuable contract ever won by the company, including the design and supply during the period up to 2013 of 15,000 m² of retaining walls, 6,000 m² of bridge abutments, 10,000 m² of two-phase walls with TerraClass® facings, and 2,000 m² of temporary wire-faced TerraTrel® walls, for a total surface of around 33,000 m².

Freyssinet to supply and fit 288 stay cables

At the same time, the works consortium accepted the bid for work on the future bridge from Freyssinet Canada Ltée, Freyssinet's Canadian subsidiary. The company will supply and fit 288 HD 2000 stay cables with their associated dampers, expansion joints and anchor components. "The stand-out feature of this bridge is that it will offer two five-lane carriageways making it, at 50 m, the widest bridge in Canada," explains Freyssinet Canada's operations manager, Franck Chavent. "Aside from that, it's a straightforward cable-stayed bridge with twin towers rising 75 m above the deck, and a total length of 2,200 m." Freyssinet started working on the bridge in March 2011.

> The stand-out feature of this bridge is that it will offer two five-lane carriageways making it, at 50 m, the widest bridge in Canada."
> Franck Chavent

Participants

Contracting authority: British Columbia Ministry of Transport
Project management: TY Lin International
Civil works consortium: Keiwit-Flatiron General Partnership
Specialist contractors: Reinforced Earth Company Ltd (Canada), Freyssinet Canada Ltée

SOLETANCHE BACHY
— Toulon Tunnel/France

Critical zone successfully crossed thanks to compensation grouting

Nobody in the team responsible for boring the second tube of the Toulon tunnel *(see box)* had forgotten the subsidence that occurred in 1996 in the zone close to the SNCF railway tracks. So it was no surprise that every possible precaution to limit surface settlement was taken (additional pre-reinforcement, reducing progress to 1 m steps) when approaching this difficult geological zone (soil washouts and soft clay) during the summer of 2009. Despite all the precautions, a 40 mm initial settlement was observed, enough to affect nearby structures and quickly leading to a suspension of work at a location where, 25 m beneath the ground, the teams had scarcely started tunnelling beneath the buildings.

It was rapidly decided to use compensation grouting. Robin Betend, who was in charge of this "project within a project", describes the technique as "injecting precisely calculated volumes of cement grouting into the area between the tunnel and the structures. This is designed to limit ground decompression that may arise as a result of the earthworks." The operation began by creating a berlinoise wall and shotcrete embankment in front of the buildings and a work platform level with their foundations. Boring was carried out in two stages, in March then May and June, and 57 manchette pipes were positioned beneath the two buildings requiring protection. The pipes were an average 44 m long and were fitted with manchettes every 33 cm, making a total of over 5,300 grout holes.

Constant surveillance

Initially, small volumes (30 l per grout hole) of grout were injected repetitively across the entire surface requiring treatment, the idea being to prepare the ground by making it as homogeneous as possible. The next stage, controlled heave, involved raising the buildings by around 12 mm with a series of injections beneath the foundations. Now protected by the surface grouting, tunnelling was able to resume on 19 July, subject to an elaborate monitoring system put in place by SolData. This combined Cyclops and Centaure systems, electronic tilt meters, and strain and settlement gauges. "The system allows you to track surface and sub-surface movements on a PC display to an accuracy of around one-tenth of a millimetre (sometimes even one-hundredth with the electronic tilt meters). Readings are taken at four-minute intervals, and the data are used to control the digging and grout injections," explains Robin Betend. Every day saw a few cubic metres of grout injected in this way beneath the buildings simply to offset the settlement caused by the tunnelling below.

By mid-November the tunnel had advanced another 100 m and was now beyond the critical zone. But more injections were required; having addressed the issue of decompression, the phenomenon known as relaxation also had to be treated once the leading edge of the tunnelling had moved on.

Using cased boring techniques limits secondary settlement beneath buildings while the injection system is being put in place.

The second tube breaks through

The Toulon tunnel runs a distance of 1,818 m beneath the city, linking the A50, A57 and A570 motorways. It comprises two conventionally bored tubes. The first tube, running east-west, was built between 1993 and 2002. Work began on the second (west-east) tunnel in 2007, and the crucial breakthrough was reached on 3 March 2011, after 44 months tunnelling from the west and 27 months from the east.

NUVIA

— Anti-seismic bearings at the Cadarache site/France

Protecting against earthquakes and simplifying building design

With France's Osiris test reactor, built in the 1960s, set to shut down soon, the French Alternative Energies and Atomic Energy Commission (CEA) planned and began work on a new experimental reactor at the Cadarache site in southern France in 2009. The new reactor is called the Jules Horowitz* reactor (RJH) and its special design feature is its anti-seismic bearings. The reactor building and its annex form a monolithic complex resting on 195 special NTI-ABS type bearing pads, the main purpose of which is to isolate the structure in the event of an earthquake. These bearings have unrivalled durability (70 years) and very precisely meet the full range of seismic loads. They were jointly developed by the CEA and Nuvia starting in 2003 as part of the RJH and Iter (International Thermonuclear Experimental Reactor) projects in Cadarache. They are also the result of synergies with Freyssinet, which specialises in the design and production of bearings and contributed its experience to Nuvia Travaux Spéciaux (NTS).

The first stage of the work, involving systems design and qualification, took place between November 2005 and October 2007. It was headed by NTS, which coordinated design capabilities (Freyssinet technical department) and industrial plant and equipment (Freyssinet Products Company – FPC). During this stage, a large number of test campaigns were carried out in the group's laboratories. It ended in November 2008 with the validation of the design and the signature of the supply and installation contract for the RJH. NTS subsequently developed and qualified the installation methods and validated them using full-scale mock-ups to ensure compliance with the stringent requirements.

At the site, where work began in October 2009, each system was placed and adjusted at the top of the posts and then fitted with formwork for sealing. The operation proceeded in two stages: a first concreting to a height of 19 cm using Foreva® Premix C500 self-placing concrete and then keying with Foreva® mortar, using a device and a method developed and qualified by NTS to prevent bubbles from forming at the mortar-bearing interface. The project was completed on 30 January 2010.

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01 - 02 NTI-ABS anti-seismic bearings developed by NTS were used in the RJH and Iter projects.

** Jules Horowitz (1921-1995) worked with other CEA and EDF engineers to develop the first industrial power generation reactors. He also helped to build the major nuclear research facilities in Europe.*

Participants

Client: Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA)
Project manager: Areva TA
Main contractor: BEC Razol
Specialist contractor: NTS (Nuvia)

A way to simplify structures

The NTI-ABS anti-seismic bearing system was developed and qualified for the RJH and Iter projects. Following discussions with F4E, the programme manager of the Iter project, NTS was selected to supply and install bearings of this type. Seismic protection offers benefits that transcend these two projects, however, and generate substantial financial savings for clients. Because these bearings reduce the forces and accelerations transmitted to the structure, civil engineering-process (reactor, primary circuit, etc.) connections can be optimised. Above all, ground and structural issues can be addressed separately, simplifying the building's design and facilitating standardisation.

FREYSSINET
— EPR in Olkiluoto/Finland

Freyssinet post-tensioning is the third safety barrier of Areva's new EPR reactors

A key milestone in the construction of the EPR *(see box)* in Olkiluoto, Finland, was reached on 15 October 2010 when Freyssinet completed the prestressing of the nuclear containment. This cleared the way for the civil engineering teams to begin building the second protective barrier of reinforced concrete, a special feature of this new-generation reactor. "After concluding the first phase of our work at the site, which consisted in positioning the prestressing ducts as the civil works proceeded, in March 2010 we needed to install and post-tension the 270 cables. We did this at an accelerated pace," says Jean-Lucien Mongauze, who heads the project.

The company has a lengthy track record in nuclear post-tensioning work, but this project was unprecedented. The Areva specification called for tendons with strength one and a half times greater than those employed for the previous generation of reactors (N4 type tendons) so the decision was taken to use 55 T 15 cables (55 strands with a diameter of 15.7 mm) instead of 37 T 15 cables (with 37 strands). This choice of cable, which required system approval from the European and Finnish authorities, also entailed the use of a number of special execution methods. They included the establishment of equal tension among the strands prior to final tensioning of the cable (Equitension® process) by means of an equitension jack patented by Freyssinet; and the use of a special grout, FreyssiFlow®, without bleeding and without injection vents.

01

01 The first phase of Freyssinet's work, from June 2005 to March 2010, consisted in placing the cable ducts according to a rigorous schedule as the civil works proceeded.
02 Following containment concreting, the second phase consisted in installing the prestressing cables, applying the Equitension® process and post-tensioning the cables.

Participants

Client: TVO (Teollisuuden Voima Oyj)
Project manager: Areva
Specialist contractor: Freyssinet

02

EPR: competitiveness and safety objectives

The EPR (Evolutionary Power Reactor) developed by Areva is a third-generation nuclear reactor designed to offer better economic competitiveness and increased safety in use. The EPR has four emergency cooling systems, a leaktight containment around the reactor, an extra container in case of core meltdown, and a protective envelope of reinforced concrete around the nuclear containment. In addition to the EPR in Olkiluoto, three other units are under construction: one in Flamanville, France, and two in China.

01

01 - 02 The cased secant piles are completed using a 22 m high drilling rig weighing about 100 t.

02

SOLETANCHE BACHY

— Preston Shafts/UK

Cased CFA secant piling for nine hydraulic structures

From May to December 2010, Bachy Soletanche Ltd participated in the construction of a large wastewater project in Preston, Lancashire (UK). The facilities will collect and treat stormwater that currently goes into and pollutes the River Ribble, which flows into the Irish Sea some 20 km west of the city.

The installation is being carried out for United Utilities, which will operate it. It consists of several structures built on either side of the river: on the south side, a deep 27 m diameter shaft adjoining a 22 m deep screening chamber and a 17 m diameter shaft; and on the north side, nine shafts averaging 26 m in depth. "All these structures are connected by a 3,500 m tunnel constructed 30 m below ground," says Paul Hodgson, development director at Bachy Soletanche Ltd. "This enables the wastewater collected by the shafts on the north side to be transferred to the facilities on the south side for treatment."

A technique with several advantages

The large structures on the south side are made of conventional diaphragm walls, but a different technique, cased CFA secant piling, was used to build the shafts on the north side. In this solution, piles are bored and concreted like conventional CFA piles, but with temporary casings. It was selected for several reasons.

"This technique offers many advantages," says Paul Hodgson. First, it is more suitable than a diaphragm wall because on the north side the company is working in a residential area close to the river, where cased secant piles offer greater leeway in terms of the shape of the shafts and cause less disruption (vibrations) for local residents. Also, they do not require the use of bentonite as a perforation fluid, so there is no risk of this substance being discharged into areas near the river. For this application, the CFA/CSP technique is also superior to conventional CFA piling because it makes it possible to achieve large diameters (880 mm) and offers improved verticality tolerances (1:150); this is crucial to prevent leakage at the joints of secant piling retaining structures below the water table. "And lastly," says Paul Hodgson, "we have combined the quality of a bored pile and the productivity of the continuous flight augur – we've been able to complete the piles at a rate of about eight per day."

Participants
Client: United Utilities
Works: KMI Water joint venture (Kier Construction, J. Murphy & Sons, Interserve Project Services)
Specialist contractor (retaining structure works package): Bachy Soletanche Ltd

NUVIA

— Radioactive sludge stabilisation in Winfrith/UK

An unusual contract and a technical service managed from design to decommissioning

Mission accomplished! In mid-June 2010, Nuvia Limited successfully completed the first intermediate level waste (ILW) treatment operation ever entrusted to a private-sector company in the UK. "This exciting project began in 2000," says Keith Collett, managing director/CEO of Nuvia Ltd. "That was when our bid was accepted by the site licence company, RSRL (Research Sites Restoration Limited), to design, build, commission and operate a waste treatment plant to stabilise about 380 m^3 of radioactive sludge generated during operation of the SGHWR reactor in Winfrith, Dorset."

The sludge had been stored in four concrete tanks at the former UKAEA research site since the reactor was shut down in 1990. Its radioactivity was relatively low but its high carbon-14 content prevented it from being accepted for disposal at the Low Level Waste Repository (LLWR) site in Drigg, Cumbria. When the decision was taken to decommission the facility, it was clear that the sludge would have to be dealt with. "That is how the WETP (Winfrith East Treatment Plant) came to be built. It's a special plant connected to the tanks through underground pipes and designed to receive and stabilise the radioactive sludge in 500 litre stainless steel drums," says Madoc Hagan, who is in charge of the plant.

The operational process, which got under way following approval in 2007, consisted in fluidifying the sludge and pumping it from the tanks to the treatment plant, where it was mixed to an approved formulation, encapsulated in drums, hardened and taken to the site's Treated Radwaste Store. After gradually ramping up production to 50 drums per month at the height of activity, the operation was completed in April 2010. A total of 1,068 drums were produced.

Unexpected materials

The last two stages of the operation were the most difficult. The first consisted in treating the thicker sludges, the "bulk heel", which unexpectedly proved to contain gravelly materials and a variety of extraneous items. The recovery of the residual sludge at the bottom of the tanks (the "final heel"), where sandy materials were concentrated, required a number of adjustments. A total of 3 m^3 of materials were recovered and placed, in batches of 15 to 20 kg, in 186 drums in order to remain within the LLW standards.

With the operation now completed, the WETP installations are being dismantled. But for Nuvia Ltd and for RSRL, the operation remains a real achievement. "It was an ambitious project that called on the full range of our company's expertise and gave us substantial experience in waste sludge treatment," says Keith Collett, and according to RSRL operations director Andy Staples, "the project was a key milestone in the site remediation process."

** SGHWR: Steam Generating Heavy Water Reactor.*

Participants

Client: Research Sites Restoration Limited
Project manager: UKAEA
Specialist contractor: Nuvia Limited (design, construction, commissioning and operation of the plant)

02

01

01 Overview of the plant (on the left). The building on the right houses the storage tanks.
02 Pumping equipment inside the WETP.

Q&A

Rowland Cornell
Technical consultant

Did this work expose operators to ionising radiation?
In the design and preparation phase, the full range of measures were adopted to minimise operator exposure, but the unexpected discovery of materials with a diameter exceeding 2 mm as well as the discovery of sandy materials, did have an effect.
The collective effective dose received in the recovery and stabilisation of these materials was 5.3 and 7.5 mSv respectively. The eight operators who worked at the storage tanks, and the WETP itself, never exceeded the dose

SOLETANCHE BACHY

— Port of Cotonou/Benin

Two new berths to boost port activity

As part of the fight against poverty, independent US foreign aid agency Millennium Challenge Corporation provided a $307 million grant to assist Benin in a variety of fields (justice, finance, trade and infrastructure). Part of this grant, $170 million earmarked for the country's "access to markets", was invested in a variety of works to improve the efficiency of the Port of Cotonou, the country's economic lung. The main work involved building two new berths.

Soletanche Bachy won the general contract in August 2009 and is working on the project with the Sogea-Satom (VINCI Construction) teams. The project covers construction of a 546 m long quay on the undeveloped southwestern bank of the inner harbour and a 114 m rear quay. "The structure consists of two diaphragm walls," says construction manager Sara Cascarino. "The first, which is 1 m thick, extends 30 m below the natural terrain and the level of the future quay (HZ* +3.50 m hydrographic level). This constitutes the quay wall, which serves as a retaining wall and supports the crown beam and equipment. The second is 0.60 m thick and is built 30.50 m behind the main quay. It is 9.50 m deep and serves as an anchor wall and foundation for the rear rail of the gantry crane. Except for a limited area of the bank that will have to be consolidated, it was not necessary to reclaim land from the sea and all works are being carried out on dry land."

Coping with a tight schedule

Work got under way in October 2009 with a geotechnical campaign. The project was suspended for six weeks in the summer of 2010 due to a malfunction in the safety system of a nearby gas terminal. By mid-November 2010, 55% of the walls had been completed and work on the crown beam started. In the run-up to the start of earthworks, the first shafts were being bored at the site to perform pumping tests and ascertain the resources needed to draw down the water table. "There is an intermediate layer of clay within these fine sands, so a shaft every 15 m and 15 to 30 m^3 pumping equipment should suffice to ensure dry earthworks – the sand is far less permeable here than it is in Le Havre," says Sara Cascarino, who, like many young engineers working for the company, gained part of her early experience on the Port 2000 project.

On the land side, 270 anchors with a diameter of 90 mm remain to be placed at 2.20 m intervals in the spaces left in the walls at HZ –3 m in the forward and HZ –1 m in the rear wall; and on the water side, dredging to HZ –15 m remains to be carried out. To make up for the delay due to resumption of work after the six-week interruption and the postponement of a number of technical decisions, Soletanche Bachy has made proposals to the client aimed at speeding up the project (working every Saturday instead of every other Saturday; introducing a night shift for the excavation work). This will enable it to complete the works in August 2011 and close the accounts before the end of October 2011 as provided in the American financing plan.

** Hydrographic Zero.*

Participants
Contracting authority: Millennium Challenge Account (MCA)
Project manager: Royal Haskoning Nederland BV
General contractor: Soletanche Bachy (subcontractor selected to supply the concrete mixing plants, earth moving equipment and civil engineering teams: Sogea-Satom)

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01 - 02 Overview of the worksite at the start of works and at the beginning of earthworks.
03 Safety meetings are organised for each shift every week and before the start of a new phase of the project.

Q&A

Sara Cascarino
Works Package 2 works director

Were any special safety and environmental measures taken on this project?
MCA has stringent accident prevention and safety requirements and makes sure they are complied with by organising regular audits. The workers on this project therefore enjoy better conditions than local standards provide for, in terms of health (medical check-up, disease-avoidance training, etc.) and equipment. When it comes to the environment, we must comply with the same standards here as in Europe. The project even had an outstanding biodiversity component. Since the dredged sands were to be spread on beaches where turtles nest, a very large-scale system was planned to monitor and protect them. Ultimately it was not necessary to implement it, because the suspension of the project over the summer of 2010 delayed operations during the nesting season.

01

SOLETANCHE BACHY

— Fishermen's Wharf, Abu Dhabi/United Arab Emirates

From methods conundrum to innovation

As part of its land reclamation work to extend the city of Abu Dhabi, the NMDC (National Marine Dredging Company) filled in a 1 million m^3 platform on Saadiyat Island next to the bridge of the same name. This project was completed in October 2008 by Freyssinet following two years of works. In November 2009, NMDC placed an order with Soletanche Bachy for a diaphragm wall quay needed for the ongoing urban development. As in the case of similar structures built in the region, such as Al Raha Beach and Jumeira Palm, the front wall of the quay was to be faced with prefabricated panels. However, in this case the standard facing panel installation process could not be employed due to the configuration of the location. So the worksite team came up with an original method.

"Usually," says agency contract manager Xavier Iltiss, who has experience with this type of structure, "the prefabricated panels are installed after the diaphragm wall is built, by digging to the required depth and applying them to the front face. Here, we were unable to do so because there was too little clearance (between 4 and 5 m) between the structure and the bank, and also due to the tight schedule." The panels therefore had to be incorporated during construction of the diaphragm wall, rather than being placed afterwards, "which was a problem because we couldn't remove the formwork before the concrete set, which meant we couldn't achieve a perfect separation joint." During the methods phase of the project many avenues were explored but none were deemed suitable for the scale of the project or the client's quality requirements. Ultimately, the engineers went back to square one to devise a new construction system and develop tools *(see opposite)*. With this original, innovative process, for which a patent has since been filed, what was previously a two-stage operation can be carried out in one fell swoop.

The project, completed in June 2010, began in January with preparatory ground consolidation by means of vibro compaction, followed by the execution of the diaphragm wall using two KS machines (hydraulic bucket excavators) in alternating shifts. The free standing wall (i.e. without ground or secondary wall anchors) is 780 m long and extends to a depth of 18 m.

Participants
Client: Port of Abu Dhabi
Project manager: National Marine Dredging Company
Specialist contractor: Soletanche Bachy

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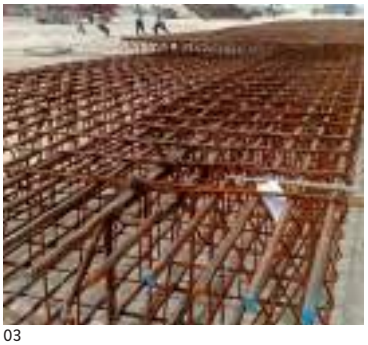

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01 The completed structure with its prefabricated facing panels.
02 The principle of construction is based on a modification of the panel separation joint and the use of a polystyrene plate to wedge and protect the sides of the panels. Four reinforcement bars in the lower part connect it to the reinforcement cage.
03 In the upper part, the thickness of the reinforcement cage is reduced to make room for the prefabricated panel.
04 A special lifting device supports the reinforcement cage and leaves a sufficient opening to place the prefabricated panel.

TERRE ARMÉE

— Double Track Ipoh-Padang Besar/Malaysia

100,000 m² of Reinforced Earth® retaining walls along a 330 km railway line

In December 2007, the MMC-Gamuda joint venture was appointed by Keretapi Tanah Malayu Berhad, the Malaysian railway company, to design and build a double-track electrified railway line between Ipoh and Padang Besar over a distance of 330 km, as a replacement for the existing line. Better known as 2T (Double Track), this project included the removal of all the level crossings, replacing them with bridges or underpasses requiring large areas of Reinforced Earth® walls, together with the construction of Reinforced Earth® walls for the retaining walls and abutments of the numerous civil engineering structures crossing rivers and motorways.

In September 2008, Reinforced Earth signed a contract with MMC-Gamuda for the supply of a total of 100,000 m² of Reinforced Earth® walls, which made it by far the largest contract ever signed in Malaysia.

Having worked with Gamuda for more than 20 years, Reinforced Earth Malaysia was thus able to benefit from the relationship of trust it had formed with its partner and to confirm the technical and financial advantages of Reinforced Earth® retaining walls in the construction of railway structures. A few figures suffice to give an idea of the scope of the project: 330 km between the north and south ends of the site; four precasting sites; 150 sets of panel formwork; more than 100 structures and 64 Reinforced Earth® interchanges to be constructed.

Manufacture of the panels began in September 2008, followed by installation from February 2009 onwards. Work is expected to be completed by September 2011.

Participants

Client: Keretapi Tanah Malayu Berhad (Malayan Railways Limited)/Kinta Samudra/Emenea PMC SDN BHD/Techart pmc
Project manager: Malaysian government
Main contractor: MMC Berhad and Gamuda Berhad joint venture (MMC-Gamuda)
Specialist contractor (design and construction of Reinforced Earth® structures): Reinforced Earth Management Services Sdn Bhd (Rems)

One of the many Reinforced Earth® retaining walls built along the 330 km Ipoh-Padang Besar railway line.

01

MENARD/ SOLETANCHE BACHY/ FREYSSINET

— Port Botany, Sydney/Australia

Comprehensive compaction contract for the extension of the container terminal

During the first decade of the century, the unprecedented growth of trade and commerce in Australia frequently led to organisations constructing or extending their infrastructure works on land that had previously been considered unsuitable or unusable. This was the case in 2007 for the Sydney Ports Corporation, in New South Wales, which decided to enlarge the container terminal at Port Botany by constructing a new 1,850 m dock with five piers and to create, behind it, a 60 ha storage area reclaimed from the sea by backfilling 7.8 million m^3 of sand.

Programmed to open in 2012, the design and build project was awarded to a joint venture formed by Baulderstone and Jan de Nul. Right from the tender and preliminary design stages, Austress Menard, which has had a commercial relationship with Baulderstone for many years, was approached to provide an estimate and technical advice in connection with the deep compaction of the backfill. The proposed solution, studied in association with Vibro-Services (a subsidiary of Soletanche Bachy), whose parent company had just joined VINCI, combined vibro compaction (vibroflotation) and dynamic compaction, the two techniques in which these companies excel. The proposal was accepted by the client, who, in the summer of 2008, awarded Austress Menard an AUS$18 million contract for all of the deep compaction works in the project.

The works were broken down into several phases – maritime vibro compaction, land vibro compaction and dynamic compaction – carried out over a period of two years at the same time as the execution of the dredging and the construction of the dock. This schedule required tight coordination of the contractors.

Work started in November 2008 with the compaction works (vibro compaction and dynamic

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compaction) needed for the construction of the precasting and storage area for the counterforts from which the dock is constructed and a temporary dock for loading the counterforts onto a barge especially designed for their installation. While 200 of these 600 t units were being manufactured, the sea bottom, comprising loose sand and silt, was excavated down to a depth of 30 m below sea level, and then backfilled with 800,000 m^3 of clean sand, obtained from Botany Bay. This backfill was compacted using a V48 vibrator mounted on a 130 t crane on a barge, set to an altitude of -17.50 m. This compaction phase was completed in March 2010, at the same time as the installation of the counterforts. During the same period, the container platform was constructed behind the counterforts by hydraulic backfilling using the sand dredged from the bay. A 45 m zone located immediately behind the dock wall had to be consolidated by vibro compaction for a depth of 20 m, using land-based resources (i.e. a V48 vibrator suspended from a 100 t crane). At the same time, the remainder of the terminal, an area of approximately 450,000 m^2, was consolidated down to a depth of up to 13 m by high-energy dynamic compaction, carried out using two Liebherr 885 HD cranes from Menard, releasing pounders of 25 t from a height of 23 m. The work was completed in December 2010.

01 Dynamic compaction rigs.
02 Aerial view of the site, showing the reclamation from the sea.
03 Vibro compaction rig.
04 Supply of material to the vibro compaction rig.

Participants
Client: Sydney Ports Corporation
Project manager/general contractor: Baulderstone-Jan de Nul joint venture
Specialist contractor: Austress Menard (in association with Vibro-Services), which became Menard Bachy in December 2009

A platform reconstruction by Freyssinet

In August 2010, not far from the terminal extension site, Freyssinet Austress, with technical assistance from Freyssinet structural engineers in Bangkok, was appointed as a general contractor by Patrick Stevedores, the main container terminal operator in Australia. The project involved very extensive works for the reconstruction of a platform with a badly damaged asphalt finish. As it was not practicable to reconstruct the platform in exactly the same way or with paving slabs, the client chose to use the solution of a post-tensioned prestressed slab proposed by Freyssinet, which would be less expensive and faster to install. Subcontractors have been appointed to carry out the work, which will involve six areas of approximately 10,000 m^2 each requiring around four weeks each to complete. Completion is programmed for spring 2012.

A grid of Geomix® retaining walls will provide earthquake protection for the new buildings.

SOLETANCHE BACHY

— Fort de France prefectural headquarters/Martinique

First application of the Geomix® process as a ground improver

The major earthquake suffered by Martinique in 2007 showed once more the urgency, for the prefectural authorities, to construct two new administrative buildings as a replacement for one older building. The call for tenders issued for the construction of the foundations sought two technical solutions: one, very traditional solution, using piles and barrettes; and the other, on the face of it less expensive, using ballasted columns and rigid inclusions. The objective, in both cases, was to transfer the load from the buildings onto "good" ground through the layer of alluvial sands, at a depth of 12 to 19 m on the site.

"Although, obviously, there were no feasibility problems with the technique of piles and barrettes," explains Emmanuel Ollier, the head of Bachy Fondaco Caraïbes, "the envisaged ground improvement solution did not seem to us to be suitable, bearing in mind the great thickness and the high potential for liquefaction of the ground in Fort de France. In the event of an earthquake, at the final stage of deterioration, the ground actually 'flows', depending on the angle of inclination of the upper surface of the substrate. In this case, the difference in level of the top of the good ground is substantial, as it is up to 7 m over a length of only 40 m. Rigid inclusions and/or ballasted columns would not therefore be strong enough to withstand the intensity of the forces created by an earthquake."

Not wishing to waste the opportunity of putting forward a cost-effective alternative to the basic solution, Bachy Fondaco Caraïbes proposed a grid of Geomix®* walls 0.50 m thick under the whole building, on a layout of approximately 4.30 m by 4 m. This unusual alternative has a number of advantages: it blocks liquefaction of the ground in the event of an earthquake and, during the works phase, it causes less disturbance (vibrations) for neighbours. It also reduces to a minimum the need to use machinery on the site, as the process generates very little spoil and only requires a limited supply of cement and water.

Although it was not the least expensive bid submitted, Bachy Fondaco Caraïbes' tender was accepted as being the best for the construction of the foundations for the two buildings. One is a four-storey and the other a five-storey, with a total ground area of approximately 600 m^2 each (i.e. a total of 1,115 m^2).

"This new technique, implemented over a very short period of time between mid-October 2010 and mid-January 2011, represents a big step forward in the approach to foundations in a seismic zone," considers Emmanuel Ollier. "If generalised, it could create a revolution for us, encouraging us to obtain the appropriate plant and develop this new expertise."

** Geomix®: a retaining wall and foundation process combining Hydrofraise trench cutting with deep soil mixing.*

Participants
Client: French Ministry of the Interior
Client representative: Direction Départementale de l'Équipement
Project manager: DHA joint venture (Arch'Îles Concept, CIEC Engineering)
Deep foundations package: Bachy Fondaco Caraïbes

MENARD
— A72 and A71/Germany

The Mars process was the obvious solution for two motorway projects

Twenty years after reunification, Germany is still continuing its programme to upgrade infrastructure, in particular motorways, in the former GDR. Two major roads are currently under construction in Thuringia that, in the long term, will connect Berlin to the south of the country, via Magdeburg and Erfurt (A71), and to the Czech Republic via Leipzig and Chemnitz (formerly Karl-Marx-Stadt) (A72). About 100 km apart, these two construction sites cross zones in which the ground is unstable due to the presence of underground cavities created by the dissolution of pockets of gypsum, which have to be treated before the motorway itself can be constructed. Back in 2006, the teams constructing the A71 had already confronted this type of problem in the region of Erfurt. The client, Deges, which is the company programming and constructing the infrastructure for the new *Länder*, once again opted for the solution of high-energy dynamic compaction developed by Menard under the name of Mars (Menard Automatic Release System). This is an alternative to the conventional solution of injection, which is a very expensive process.

"This exclusive process, a perfect example of Menard's constant innovation, was developed by us in 2004, for a project in the Middle East that required compaction energy well in excess of the levels achieved by our usual plant," recalls Jean-Luc Chaumeny, manager of BVT DYNIV GmbH, Menard's German subsidiary. It consists of dropping a 35 t pounder (as compared to 15 to 17 t normally) onto the ground using a grab system that is hydraulically controlled, thus avoiding the energy losses of 30–40% in the drum and in friction in the cables. The "free fall" of the pounder develops a level of energy of 1,050 tm (tonne metre). "Overall, the level of energy achieved using the Mars process exceeds 600 tm/m^2 (as compared to 200 to 300 tm/m^2 usually), which is perfectly capable of breaking up the voids and of consolidating zones of dolines* within the 15 m depth in which they create a risk for the construction of the platform."

Patented in 2004 and perfected since then by Menard's plant department *(see* Resonance *No. 2, p. 38)*, the Mars system was used once again in Germany in March 2010 on the A72 motorway site. The work consisted of treating a zone of approximately 80,000 m^2, in which the soil investigations had identified voids, and in which the initial earthworks had caused collapses and spectacular holes several metres across. The crane fitted with the Mars system was used as an initial treatment, followed by a traditional dynamic compaction rig. Following the completion of its work on the A72 in June, Menard's Mars rig was transferred to the A71 site, where the area to be treated was approximately 45,000 m^2. The compaction works on both sites were complete by the end of 2010.

Use of the Mars system allows the level of the compaction energy to be doubled.

** Doline: small circular or elliptical depression formed by a naturally backfilled zone of collapse.*

Participants

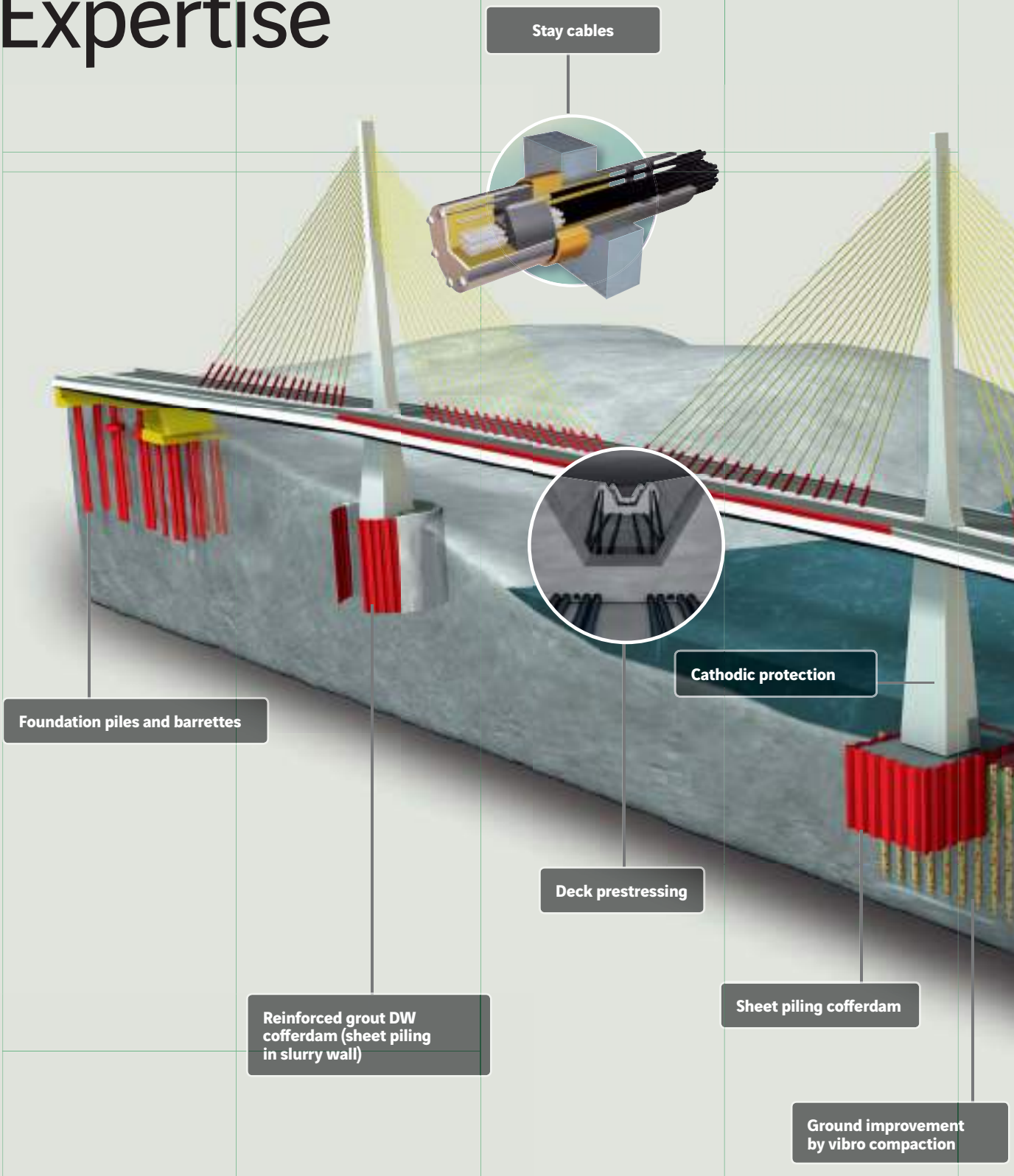
Client: Deges (Deutsche Einheit Fernstraßenplanungs- und -bau GmbH)
Project manager: GuD Geotechnik und Dynamik GmbH
A71: joint venture contractor: BVT DYNIV GmbH (lead company)/Heilit+Wœrner Bau GmbH
A72: earthworks: Hermann Kirchner Bauunternehmung GmbH
Specialist contractor: BVT DYNIV GmbH (Menard)

Q&A

Jean-Luc Chaumeny
Manager of BVT DYNIV GmbH

How is Menard's business organised in Germany?
The company returned to Germany following the completion of a very large contract for the extension of the EADS plant in Hamburg in 2004, by creating a subsidiary BVT DYNIV GmbH, based in Seevetal (Lower Saxony), and then an agency in Stuttgart in 2009. Before 2008, the business was mainly centred on ground improvement works on logistics platform sites. With the recession, it extended to works on the infrastructure for the economic recovery plan, but it is currently benefiting from the increase in the development of industrial zones. We foresee the opening, in the near future, of a new agency in the centre of Germany.

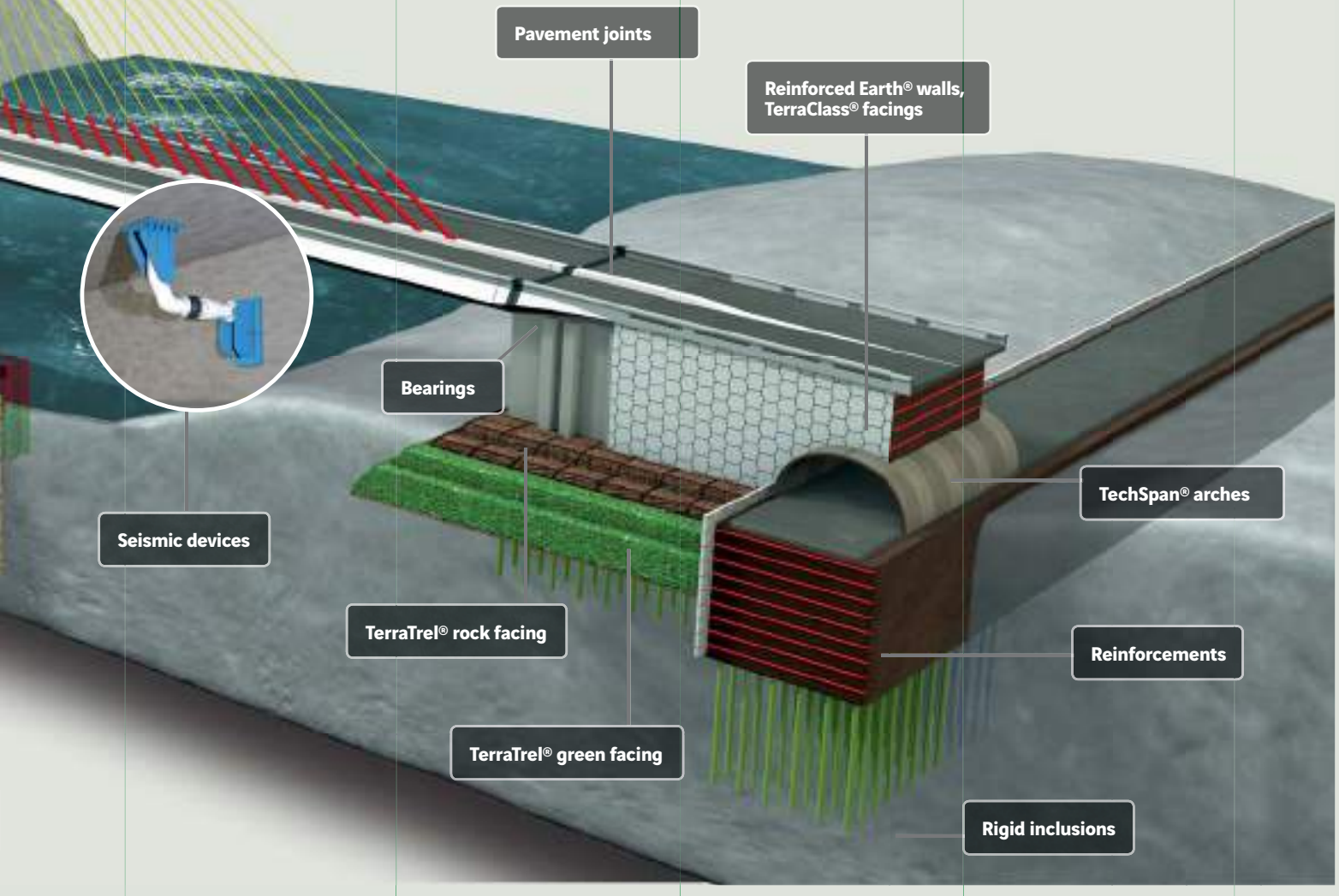
Expertise


Stay cables
Cathodic protection
Foundation piles and barrettes
Deck prestressing
Reinforced grout DW cofferdam (sheet piling in slurry wall)
Sheet piling cofferdam
Ground improvement by vibro compaction

Engineering structures: cable-stayed bridges

Cable-stayed bridges have the advantage of being self-supporting, with the central span and lateral stay cables balancing the horizontal forces in the tower and the deck. This is unlike suspension bridges in which the deck is suspended from vertical cables attached to two support cables that must be anchored to the banks in imposing structures.

For the construction of this type of bridge, **Freyssinet** offers the full range of its experience and know-how (stay cables, prestressing, seismic devices, cathodic protection, bearings, pavement joints, etc.); this expertise supplements that of **Soletanche Bachy** and **Menard** in foundations and ground improvement and of **Terre Armée** in abutment and approach span retaining walls.



Expert voices

Chris Hendy, Head of Bridge Design and Technology, Atkins plc.

"Cable-stayed bridges are an optimum form of construction"

Since cable-stayed bridges were first built, their structures have steadily been getting lighter and their spans longer *(see p. 10)*; this has entailed a continual improvement in the stay cables, anchorage and damping systems and other components. Chris Hendy *(pictured here)* is head of bridge design and technology at Atkins plc, a multi-discipline UK Engineer. For *Resonance*, he describes the advantages of the technique and the major changes that can be expected as new requirements come on stream.

What is your link with Freyssinet? What common projects are we currently working on?

Chris Hendy – We have worked with Freyssinet on numerous projects in recent years, including the Dubai Metro project and the Penang Bridge Stay Cable replacement project. At present we are working on the Forth Road Bridge bearing replacement project [Scotland], which involves replacement of all the roller and rocker bearings on the approach spans to the main suspension bridge. We are also jointly investigating a novel strengthening solution to an offshore oil platform using large diameter Freyssinet stay cables.

What do you think of future cable-stayed bridges in architectural terms?

Cable-stayed bridges have come to be regarded as the height of the art and science of bridge engineering and something to which all bridge engineers aspire to design in their careers. Interestingly, the public have the same impression, so there is always much pressure for cable-stayed solutions to be considered for medium- to long-span bridge problems. In many cases, the cable-stayed bridge is both the optimum form of construction, with our current material technologies, and also a visually pleasing solution. But the success or failure of both depends strongly on the architectural concept and its considerations of the context for the bridge. The wrong architectural concept will make design of the bridge very difficult, exposing it to future problems with vibration, maintenance and durability, among other problems; this is an unsustainable legacy that we should not proliferate. Insufficient consideration of the context and location for the bridge will produce unsightly results; many architectural statements made through cable-stayed footbridges would look ludicrous outside a city environment but that is the beauty and difficulty of the art of design. So provided we consider the function of the bridge, its sustainability and its environment in deriving its form, the cable-stayed bridge will continue to be a vehicle for both architectural flare and structural efficiency.

What are the requirements to take into account for future cable-stayed bridges?

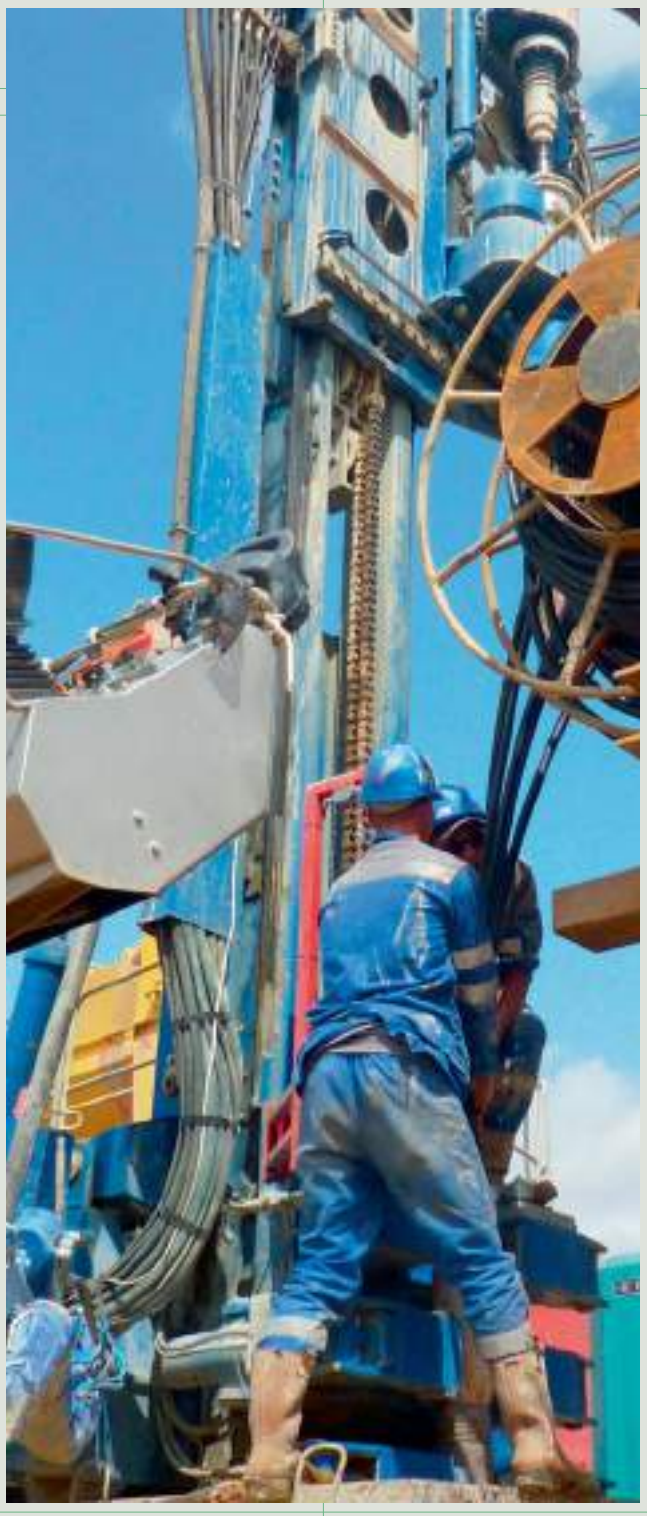
With our current knowledge of climate change and sustainability as a whole, future bridges must be designed to be more sustainable than before. Specifically, they should be durable; should minimise, but facilitate, maintenance activities; should be adaptable for future changes to function; should consider future increasing traffic demands; and should, as far as possible, be resilient to reasonably foreseeable accidental actions, such as fire and earthquake. In short, we cannot afford to procure on the basis of minimum initial cost; whole life cost and carbon are key. These demands apply to all bridges but cable-stayed bridges have some specific demands. Stay vibration issues are now well understood but not mastered. There are still numerous cable-stayed bridges exhibiting large vibration amplitudes whose impact on fatigue life is difficult to predict. Current stay cable anchorages attempt to filter out the bending stresses produced so that fatigue design can be based solely on variations in axial force, but more investigation is required to determine both realistic bending effects and the fatigue behaviour (S-N curves) for stays in bending. Atkins, together with Denmark Technical University, is carrying out research at present into this topic. Fire design is also an issue. For many bridges, a lorry fire could potentially remove more than one cable if additional protection is not provided, but the provision of additional protection is usually unsightly at present and needs improvement. And, although multilayer corrosion protection as now used in all new designs is a good protector of cables, we need to further consider the use of corrosion resistant materials to form main stay elements in order to prolong or eliminate the need for cable replacements on the grounds of deterioration.

In your opinion, how do Freyssinet's technologies match the market's expectations and evolutions?

Freyssinet, in my opinion, has always responded well in matching its products and services to meet the developing understanding of structural behaviours (such as damping out cable vibration), the demands of the construction process (such as the provision of tolerance in anchorage systems) and the needs of bridge owners (such as maintainability, replaceability and the provision of monitoring systems). I look forward to continue working with Freyssinet as we all address the new challenges.

Business
MCCF's geothermal products and services

When geothermal energy was developed as a new source of renewable energy for heating housing units in the mid-2000s, it held out prospects for MCCF, one of Soletanche Bachy's specialist subsidiaries. With its know-how in drilling and injection, the company offers the expertise needed to install the geothermal boreholes used in the technique. "MCCF began operating in this business activity in 2007 after acquiring the necessary equipment. It began by installing small projects for individual homeowners," says Bruno Demarcq, who heads the geothermal department at MCCF. It then turned to larger-scale projects, a move confirmed in 2009 with the new ENSTA (National Institute of Advanced Technologies) premises in the Paris-area town of Palaiseau, a project which covers a built surface area of 36,700 m^2 over 6 ha of land. "The ENSTA project also sets challenging environmental objectives," says Bruno Demarcq. "The goal is to achieve dual HQE (high environmental quality) certification covering both construction and operation, and the project employs a combination of three renewable energy sources: very low temperature geothermal energy to meet 50% of the heating needs, solar energy to produce hot water, and photovoltaic energy to generate a part of the electricity required." The contract was awarded by the Ministry of Defence, as a public-private partnership (more specifically, an *AOT-LAO* temporary occupancy authorisation-lease with purchase option contract) with an initial duration of 30 years. Even before contract signature, MCCF provided a first service for the programme manager, Sogeprom, a member of the Génécomi[1] consortium that had submitted a bid. In October 2009, a test borehole was drilled to a depth of 160 m in Palaiseau to validate the options submitted by the Incet design office, ascertain the geological cross-section of the site and carry out the thermal response test of the geothermal borehole, which is needed to model the behaviour of the borehole field and structurally design it. To attain the 450 kW objective, 75 geothermal boreholes had to be installed at a depth of 160 m. This works out at 12 km of boreholes – the longest system ever installed on a



For the ENSTA premises under construction in Palaiseau – its largest ever worksite – MCCF installed 75 geothermal boreholes at a depth of 160 m.

worksite. MCCF's assignment did not end there. It also included the usual borehole and underground network pressurisation testing; and because of the unprecedented scale of the project, the company carried out further thermal response tests to supplement the one performed in the preliminary phase.
MCCF began these operations in May 2010, just as the roads and main services work was getting under way. Very quickly, its work dovetailed with the other works packages. The technical project manager, Coteba, therefore phased all operations in six zones. To ensure quality and safety, the MCCF drilling rigs (a Hütte HBR205 and a Solimec PSM16GT) must work on stable surfaces. Not that this rules out contingencies.

© Clotilde Richalet

MCCF's work was combined with pavement construction to enable the drilling rigs to work from stable hard surfaces.

The unanticipated discovery of sandstone banks within the Fontainebleau sands and of gypsum lentils within the oyster-rich marl – two highly indurated geological features – made it necessary to redefine the drilling method and boost the workforce so as to free up the work zones on schedule. The last phase of the project prior to completion in October consisted in "collecting" the boreholes in groups of 10 to 15 units within seven manholes spread across the green spaces, and connecting each of the latter with the other six so as to connect the entire network with the heat pumps through two pipes only – one outgoing, one incoming.

(1) Consortium made up of Sogeprom, Société Générale, Adim (representing GTM) and Cofely.

Questions for Bruno Demarcq

Head of the geothermal department at MCCF

What is geothermal energy?
Geothermal energy is derived from the heat of the earth. The generic term "geothermal energy" in fact covers a wide variety of techniques. "High temperature geothermal energy" (used to supply power turbines) and "low temperature geothermal energy" (used for district heating) require deep drilling, similar to oil wells. "Very low temperature geothermal energy", which MCCF handles, is used to heat individual buildings. In this technique, vertical thermal boreholes are typically placed at a depth of between 70 and 100 m.

How does a geothermal system work?
The boreholes installed in the ground have two "outgoing" and two "incoming" tubes, through which a carrier fluid flows. A heat pump then recovers the calories contained in the ground. In a "geothermal field", like the one installed in the ENSTA project, the boreholes are connected in parallel via a horizontal underground network and connected to one or several heat pumps. The system has major environmental advantages because it requires no exchange of materials with the sub-soil and its maintenance costs are very low.

In pictures

The Groundhog and the caterpillar

In the British Isles, the operators of the nuclear sites at Dounreay, Scotland and Sellafield, Cumbria, have an obligation to systematically check nearby beaches for radioactive particles. Since manual inspections are extremely time-consuming and not very reliable, Nuvia has developed a special system to replace them, called the Groundhog™. Mounted on a tracked vehicle that can be operated on beaches, it produces maps with an accuracy of less than 1 metre and covers 100% of the site. The system was in use on the large beach next to the Sellafield site from 2007 to 2009, when it was replaced with a new version that is more sensitive to low-energy gamma radiation and is now placed in a carbon fibre box. It is mounted on a small tracked vehicle to limit environmental impact.

The world leader in ground technologies, structures and the nuclear sector, **Soletanche Freyssinet** has a presence in some 100 countries.
The Group offers an unrivalled range of specialist civil engineering expertise and brands.
Its 17,000 employees focus on responding to client expectations through solutions tailored to the unique features of each project and contribute to improving the technical performance and durability of structures.

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