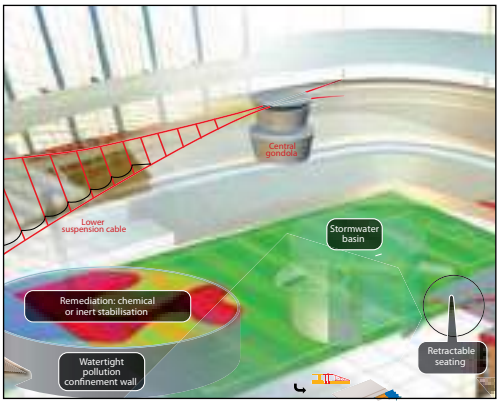
SOLETANCHE FREYSSINET



resonance

The magazine of the SOLETANCHE FREYSSINET group

Group — Menard Bachy: ground technology activities resonate in Australia
Soletanche-Bachy — Foundation works for the museum of the Arts of Islam
Freyssinet — Combined expertise for the Térénez bridge
Nuvia — RJH: a first in unbonded post-tensioning
Menard — New record for ground consolidation in the Middle East
Terre Armee — Environmental integration of the A89 motorway
Expertise — Systems and processes for stadiums

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SOLETANCHE FREYSSINET

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EDITORIAL
— BRUNO DUPETY

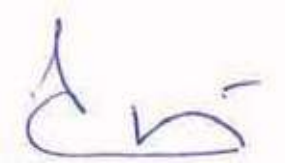
Chief Executive Officer
of Soletanche Freyssinet

> The synergies we have built so far are just the first step in a long-term process that will ultimately generate new integrated product and service offers.

The Resonance project was launched when Soletanche Bachy and Freyssinet merged. This merger not only formed a new world leader in ground technology, structural and nuclear engineering – above all, it served to build collective momentum and set in motion a process that will drive our future development. Resonance leverages the Soletanche Freyssinet group's outstanding potential for synergies across all our techniques, teams and resources. Our brands and companies – Soletanche Bachy, Freyssinet, Terre Armee, Menard and Nuvia – both resemble and complement each other. They share a culture of technical excellence and performance that supports each client's strategic goals, and deliver complementary expertise across an unparalleled array of specialised civil engineering capabilities.

This second issue of *Resonance* illustrates the group-wide momentum built up by the merger. Network synergies resulted in the founding of a new subsidiary and the development of new ground technology activities in Australia. Our design offices, human resources teams and purchasing specialists have begun working together cross-functionally. A first seminar held in September 2010 brought together more than 120 recently recruited young engineers and managers from around the world and helped accelerate the dissemination of our fundamental values and practices across all our entities. Our companies, which often work for the same clients on the ground, are capitalising on their common experience when awarded contracts for the same projects and, in a more structured approach, teaming up to put together joint bids. These are just a few examples among many.

We have come a long way in one year. We have shown that our business strategy makes sense. But the synergies we have built so far are just the first step in a long-term process that will ultimately generate new integrated product and service offers. Meanwhile, we will remain true to the principle of autonomy that enables each of our companies and brands to serve as the local partner of its clients. By making the most of each entity's inventiveness and initiative and by joining forces to better support our clients with solutions that deliver added technical value, sustainability and competitiveness, we will forge ahead with our development and enable the Soletanche Freyssinet group to come into its own.



RESONANT BUSINESSES AUSTRALIAN GROUND TECHNOLOGY ACTIVITIES "RESONATE"

The creation of Soletanche Freyssinet opened up new opportunities, enabling Soletanche Bachy to return to Australia and the group to restructure its Ground Technology business there through creating subsidiary Menard Bachy and acquiring GFWA.
Paul McBarron, managing director of Menard Bachy, and Alistair Sim, regional manager for Soletanche Bachy, explain how the deal came about and what lies ahead.

What is the story of Austress Menard and Soletanche Bachy in Australia?
Paul McBarron – Austress Menard was created in 2004 to work on geotechnical and ground improvement projects.
Alistair Sim – Soletanche Bachy left Australia in 2003, thinking it would be able to go back and work on major projects whenever they arose. Bachy of Australia was sold to the local management, which created GFWA. Soletanche Bachy acquired 15% of GFWA's shares and made the company its agent for Australia.

How did you come to get in touch with each other?
P. McB. – Bachy Soletanche Singapore was approached in 2007 to participate in the Hilton Surfers Paradise Hotel & Residences project on the Gold Coast. The company, whose parent had just joined VINCI, needed the support of a local firm and invited Austress Menard to form a joint venture to work on the project.
Once the project was up and running, the two companies started looking for other projects that could benefit from their complementary expertise. And that's how they came to develop a technical solution combining dynamic compaction and vibro compaction for the Port Botany expansion project in Sydney.

How did the creation of Soletanche Freyssinet at the beginning of 2009 change things?
P. McB. – Discussions and collaboration became even easier and more natural. It seemed obvious to us that it would be simpler and more cost-effective to work together as a single entity rather than set up joint ventures on a project-by-project basis.
It was decided to create Menard Bachy in December 2009. Then, at the beginning of 2010, Soletanche Freyssinet acquired GFWA, which is based in Perth, to extend its geographical coverage to the entire country.

What has been done to ensure the synergies between the companies are exploited to the full?
P. McB. – Two senior members of Soletanche Bachy's management team were transferred to Menard Bachy in 2009 to help win and execute diaphragm wall-type contracts. In addition, the equipment essential to the group was sent to Sydney. Similarly, GFWA's expertise was put to work on a diaphragm wall project in Brisbane. Menard Bachy, meanwhile, transferred two senior executives to the Perth office to support the growth of ground improvement business in Western Australia.

What impact have the synergies had on business?
P. McB. – Following on from the Hilton diaphragm wall project, Menard Bachy is building three retaining walls in Brisbane and Melbourne. The company has also won its first contract for grout injection using the Grouting Intensity Number (GIN) method for the Cotter Dam near Canberra. In Perth, GFWA has won a big jet grouting project and a diaphragm wall project.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02

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01 Strengthening the backfill in Port Botany, Sydney.
02 Erecting a diaphragm wall on a ground rehabilitation site in Melbourne.
03 Paul McBarron, managing director of Menard Bachy.
04 Alistair Sim, regional manager for Soletanche Bachy.

What are your goals and what prospects have opened up as a result of this organisation?

A. S. – We want to see Menard Bachy and GFWA capture a bigger market share in Australia, promote Soletanche Bachy's techniques, processes and subsidiaries, and offer our clients the whole range of Soletanche Bachy and Menard ground improvement services.

P. McB. – International demand from gas and mineral producing countries remains high despite the global financial crisis. Since export infrastructure has reached its capacity limits, there are going to be significant needs for port, dock and storage facilities. In addition, big cities have never-ending needs for roads, tunnels and railway lines. These all add up to an excellent source of projects.

On 29 July 2010, a Soletanche Freyssinet delegation took official delivery of the new grab in Pitesti, Romania.

Innovation

Freyssinet Products Company and Soletanche Bachy's group equipment department develop a new excavator grab

Synergies are already significant in technical solutions and business development, and are also emerging internally through the pooling of expertise. That of Freyssinet Products Company (FPC) in the fabrication of mechanically welded parts recently enabled Soletanche Bachy's group equipment department to complete a project for a new excavator grab for diaphragm walls. "It's a straightforward mechanical model," explain Pascal Plique and Patrick Malbrunot, respectively export manager and technical department methods manager at Soletanche Bachy. "We wanted its performance and reliability to be better than those of hydraulic models on difficult terrain." Bruno Zaccaro, FPC's purchasing and technical manager, adds: "Right from our initial synergy meetings at the beginning of 2009, it became obvious that this project could benefit from our technical and logistics support in the same way as projects developed by Freyssinet in the fields of prestressing and bearings." A similar industrial approach was therefore set up, supervised by three engineers. FPC proposed outsourcing the fabrication of the prototype to Metabet, one of its Romanian partner suppliers, where a team of technicians monitors the fabrication, coordination and all the checks (quality, delivery schedule, etc.). After a visit to the facilities with a view to confirming the choice of supplier and further visits during the design phase, the new excavator grab was made in eight weeks, before being tested and sent to Chile. Another two grabs are already being manufactured – and FPC says it's ready to deal with any other order for Soletanche Bachy.

Opening
Early 2010 saw Menard celebrate the opening of its new agency in Kuwait. A special cake was baked for the occasion featuring a flawless reproduction of the corporate logo, perfectly in keeping with our graphic standards!

Synergies

First meeting of the Soletanche Freyssinet group engineering and design departments

A number of in-house working groups have seen the light of day in the 18 months since the Soletanche Freyssinet group was created.

Numerous exchanges have already taken place at many levels within geographical areas and technical departments as and when opportunities arose during any one particular project. This process was given a major boost on 10 June 2010, when the engineering and design departments of Soletanche Bachy and Freyssinet met in Paris: 150 technicians came together for the first time and took the opportunity to get to know more about each others' work and skills, and to exchange the latest news and ideas about technical cooperation, which was the main focus of the meeting. Some results of this cooperation are already visible in the products and services offered by the group, in the form of packages that include technical interventions specific to each entity. A good example are technically sophisticated car parks, where the structure is retained using a diaphragm wall, and prefabricated post-tensioned slabs for each phase of the excavation are scraped into corbels and used as supports for excavation of the next stage. Another package is based on our experience of building Danish quays and the marriage of pre- and post-tensioned elements that enables us to offer lasting solutions at a lower cost for the construction of structures of this type. Furthermore, building on our mutual capabilities opens the door to the development of even more innovative solutions, combining durability with price competitiveness, such as using pre-tensioning in diaphragm walls. Several specific topics are being examined by specialist working groups, such as managing corrosion in reinforced concrete structures, where Freyssinet's skills will help to consolidate Soletanche Bachy's positions in the market for the construction of port structures, one of its historical core activities. "The process of bringing our teams more closely together, which led to the technical cooperation meeting on 10 June, has highlighted the fact that there exists within each entity the same desire to develop shared 'resonances' and innovations. Thanks to the complementary nature of our capacities and assets, we can turn this desire into a reality by developing the new solutions that the market is waiting for – and to strengthen the leading positions that Soletanche Bachy and Freyssinet already occupy in their respective sectors," said meeting organisers Christian Gilbert and Erik Mellier. As representatives of Soletanche Bachy and Freyssinet's technical departments they are already looking forward to the next meeting, to be held in Budapest in 2011.

Acquisition

Soletanche Freyssinet buys Agra Foundations Ltd

Soletanche Freyssinet acquired Agra Foundations on 25 June 2010. Agra is a Canadian company that specialises in pile foundation construction and ground improvement. Based in Edmonton, Alberta, Agra operates from seven locations mainly in western and central Canada. It will be headed by Derek Harris, who has been with Agra for the past 28 years. Agra Foundations has joined Nicholson, Menard and Géopac to strengthen Soletanche Freyssinet's presence in the provision of specialist ground and geotechnical services across the United States and Canada.

AGRA FOUNDATIONS

Acquisition
Early 2010 saw Vraco, a company that offers specialist design and manufacture of firewall equipment for ventilation circuits, join Nuvia France. Headquartered in Isère, eastern France, Vraco has developed an exclusive line of products to meet every safety requirement for nuclear environments; Nuvia's fire protection line-up is strengthened by Vraco's presence.

Distinction

A fourth President's Award for Nuvia Ltd

Nuvia won a fourth President's Award from the UK's Royal Society for the Prevention of Accidents (RoSPA) in 2010. The award, which is presented only to companies that have received a RoSPA Gold Award for 10 consecutive years, honours the efforts made over many years by Nuvia Ltd to secure lasting improvements to its workplace safety and environmental protection performance.

The 2010 RoSPA President's Award was presented to David Adams, head of HSE at Nuvia Ltd.

Safety

Posters and testimonies: prevention initiatives

Soletanche Bachy France has designed a range of tools to help ensure that its safety messages are never forgotten: themed notice boards (Prevention Information, Wear your PPE, etc.) and banners (Dare to be Cautious, etc.) for display at construction sites. Following tests at a pilot site (the Cardinet car park), these tools were distributed to all Soletanche Bachy France sites.

At the beginning of the year, all employees at EuroFrance received a DVD with their payslips, featuring testimonies from company staff who had been victims of accidents at work as well as messages from senior management. The film was also shown at every site during weekly safety meetings.

Distinction

Bertrand Petit, 2nd prizewinner at the 2010 national engineering awards

On 21 October at the CNIT in Paris, the French Minister for Ecology Jean-Louis Borloo presented Bertrand Petit, operations director for Freyssinet France, and Véronique Mauvisseau, Setec project leader, with the 2010 joint 2nd prize for engineering. Organised jointly by the Ministry for Ecology and Syntec-Ingénierie, this award is in recognition of the processes, software and cutting-edge technologies employed during the work to repair the Channel Tunnel during the period late 2008-early 2009.

New contracts

UK — Freyssinet
Scottish subsidiary Freyssinet Makers has, since March 2010, won three major repair contracts that include concrete repairs and cathodic protection, two of them as main contractor. The first two contracts concern Edinburgh's Forth Road Bridge and the 1,500 m bridge over the Cromarty Firth; the third concerns repairs to the cooling water inlet access landing stages at the Hunterston B nuclear power station on the west coast of Scotland..

Italy — Nuvia
Following an international call for tenders, in February Nuvia won a four-year framework contract to carry out surveys and works on several nuclear installations at the nuclear Joint Research Centre (JRC) in Ispra*, north of Milan. In an effort to anchor Nuvia's activities within the Ispra JRC and in Italy more generally, the group has created the Nuvia Italia subsidiary, which will in time head up all group nuclear-related activities in Italy.

** Set up in the late 1950s following the Euratom treaty, the site at Ispra houses a range of installations nearing the end of their operational lives that require rehabilitation and dismantlement.*

USA — Soletanche Bachy
Nicholson wins and heads up two major metro programmes, one on each coast. Acting for the New York Metropolitan Transit Authority, the company has constructed 19,000 m² of diaphragm wall at the 96th Street station on Second Avenue, as well as providing an extensive range of ancillary services (jet grouting, watertightness wall, bracing, etc.). At the other end of the country in Seattle, the company constructed diaphragm walls for a light metro station as part of a project linking the downtown area with Washington State University.

Canada — Nuvia
Nuvia Ltd announces its first engineering contract in Canada. The agreement, signed with Canada's main provider of nuclear power, Ontario Power Generation (OPG), provides for the renovation of four reactors starting in 2016. Nuvia Ltd and OPG will conduct a joint study seeking to establish a concept for the most appropriate design of container for the storage and transport of reactor components that this project will demand. Once the design concept is finalised, a new call for tenders will be issued for the construction, testing and approval of a prototype container.

Expert
Serge Varaksin is a technical and scientific consultant who was formerly head of export markets at Menard. After giving a series of talks in Australia at the invitation of the Australian Geotechnical Association, this autumn saw him embark on a new tour, this time visiting the UK, where in early November he gave lectures in Glasgow, Manchester and Oxford.

Training
Mecatiss trains applicators for its products in China

As part of contracts signed with Chinese companies CN123 and Huaxing, the electrical installation and civil engineering contractors for the nuclear reactors at Ling Ao (phase 2) and Qinshan (phase 2), Nuvia's passive fire protection specialist Mecatiss held several weeks on-site training for Chinese operators. The sessions extended over several weeks and were used to train over 30 operators per site in the rules and finer points of applying the Mecatiss products used to fill roof vents (935C, 935P, 75ND) and to protect cable runs in safety circuits (MPF).

Innovation
First RTE contract for Trenchmix

After three years of studies and test operations, French national electricity grid network RTE chose the Trenchmix* technology developed by MCCF (Soletanche Bachy) for its first full project. The work took place between July and September and involved strengthening some 20 pylons on the Bayet to Rulhat line.

** Developed as an alternative to the half-slab process, Trenchmix consists of creating reinforcement masses using a soil-cement mixture in place of concrete. It produces no spoil and does not require aggregates to be delivered to the site.*

Development
Creation of Nuvia India Pvt Ltd

The accelerating pace of India's civil nuclear programme and politicians' desire to seek international cooperation led Nuvia to set up Nuvia India Pvt Ltd in August 2010. Headquartered in New Delhi, this new subsidiary is headed up by Ken Jackson and Will Phytian and will have a regional presence in Mumbai and Chennai. The new company will offer engineering services and technical assistance as well as a range of specialist products and Nuvia's technical know-how to the Indian nuclear market (estimated to be worth over €120 billion).

Distinction
On 5 February 2010 in London, Bachy Soletanche Ltd received *Ground Engineering* magazine's 2010 prize for geotechnical achievements worth over £1 million. The award was recognition of the highly advanced work undertaken in 2009 as a joint venture with Arup Geotechnics on the London skyscraper The Pinnacle.

Integration

The first young managers' induction seminar: 100 young managers, five Soletanche Freyssinet specialities, 24 nationalities

The first induction seminar for young managers since the creation of Soletanche Freyssinet was held in France between 15 and 17 September. Targeting staff members with two to four years' seniority, it was the occasion for some 100 young men and women from 24 countries, predominantly engineers with an average age of under 30, to meet up together in Paris.

The seminar was divided into two sections: the first was by entity and was speciality-specific, the second brought all brands together to find out more about the group and share insights into each others' specialities. As well as presentations on senior management and carefully targeted sessions on prevention and safety, sustainable development, etc., a fun sports-based team-building activity was held in the Bois de Vincennes to highlight the performance gains from working as a team, and to lay the ground for networking in the future. The seminar wound up on the Friday afternoon with a Q&A session with management, with over 20 questions put to Bruno Dupety, chief executive officer of Soletanche Freyssinet, who took the opportunity to set out his vision and clarify certain points of strategy. One of these points – where the group will be 10years from now – offered him the chance to restate his faith in the synergies offered by the perfect fit between the specialities within Soletanche Freyssinet and his conviction that the company will be able to rely on its three fundamental strengths: its technologies, sound finances and global network.

Training

A new training centre for Salvarem

By the end of 2010, Salvarem (Nuvia) will have unveiled its second remote operation and dismantlement training centre at its site at Pierrelatte, southern France. Similar to its first training centre at La Hague in northern France, which opened in 2009, the new centre will reproduce real-life site situations, offering employees the best possible conditions under which to refresh and acquire skills, for new staff members to receive basic training and for the company as a whole to fine-tune the innovative solutions that it develops in response to its clients' requests.

New contracts

USA — Terre Armee
The Reinforced Earth Company (RECo) has recently received an order for Reinforced Earth® retaining walls as well as coatings for a total surface in excess of 110,000 m^2. This is the largest contract the company has won since it was founded, and forms part of a project for the reconfiguration of 10 freeway interchanges and the reconstruction of 55 bridges along a route to the south of Salt Lake City, Utah.

France — Soletanche Bachy
The Paris Centre Est agency was contracted in early 2010 for the construction of a six-level 609-space car park in Rue Cardinet, Paris. Built on behalf of Saemes, Paris city council's parking operations company, in association with Cosson (earthworks and site remediation), the structure is 170 m long and 15m wide.

Kuwait — Menard
After winning the ground improvement contracts for zones N1 and N3 of the Jaber Al Ahmed new town *(see p.10)*, Menard signed another deal with Ahmadiah, the main contractor. This new agreement sees Menard extend its activities into zone N2, increasing the total area to be treated from 6.8 to 9 million m^2.

France/Switzerland — Soletanche Bachy
Soletanche Bachy France and Sif Groutbor (a Soletanche Bachy subsidiary) have been awarded four works packages for the Ceva (Cornavin-Eaux-Vives-Annemasse) rail project. The first package, working in a joint venture with VINCI Construction Grands Projets and Chantiers Modernes Rhône-Alpes, concerns the construction of the Val d'Arve cut-and-cover section (12,000 m^2 of diaphragm walls). The second, a joint venture with Chantiers Modernes Rhône-Alpes, is the underground station at Eaux-Vives (35,600 m^2 of diaphragm walls, 20,000 m of anchors, 155 piles and 12,500 m^2 of shotcrete). Packages 3 and 4 were awarded later and concern the creation of cut-and-cover sections at Franck Thomas (63,000 m^2 of diaphragm walls) and Gradelle (27,000 m^2 of diaphragm walls). These two packages will be constructed by Soletanche Bachy (main contractor) and Sif Groutbor, in association with Chantiers Modernes Rhône-Alpes.

Projects

01

MENARD

— Northwest Sulibikhat and Jaber Al Ahmed new towns/Kuwait

New all-time record for ground improvement in the Middle East

From the moment it re-entered the Middle East in 2002 Menard began making a name for itself in the region with its ground improvement operations, which now total many millions of square metres. The latest announcement comes from Kuwait, where the company has signed three contracts covering a total area of over 9 million m^2 for the creation of two new towns to the north of Kuwait City: Northwest Sulibikhat and Jaber Al Ahmed.

The ground is of a type known as *sabkha* (silty clay with the water table very close to the surface), as is often the case in the region. "With a profile like this," explains Gilles Costa, director of Menard Middle East, "the conventional approach would be to excavate down to a level of at least 3 or 4 metres – therefore cutting down into the water table – and then replace the 'poor' ground with good granular material that would then have to be roller compacted."

This method is "slow, costly and environmentally problematic", so the Kuwaiti authorities decided to seek advice from the world's leading ground improvement experts before giving the project the green light. Gilles Costa explains that "Menard was able to use this opportunity to present and prove the value of using the dynamic compaction/replacement technique, cutting the amount of material to replace from 100% to an average of just 15%, avoiding working through the water table and saving a lot of time."

Menard subsequently tendered for the work, and was awarded the Northwest Sulibikhat ground improvement contract by Mushrif, the company heading up the overall project. After carrying out an initial 744,000 m^2 package during the first half of 2010, Menard embarked on a second package in July; this time 1,824,000 m^2 to be handed over in mid-March 2011. In mid-September 2009 and mid-May 2010, Menard was also awarded two similar contracts by Ahmadiah, the company heading up the Jaber Al Ahmed project, which covered respectively the ground improvement for a roadway zone totalling 3,709,000 m^2 and a 2,876,800 m^2 residential zone – with the final ground improvement contract for the remaining residential zone yet to be awarded.

Running in parallel just a few kilometres from each other, 21 compacting cranes are involved in these projects, with a workforce of over 100 people working day and night, six days a week.

Participants
Client: Public Authority for Housing Welfare (PAHW)
Main contractors: Mushrif (Northwest Sulibikhat); Ahmadiah (Jaber Al Ahmed)
Specialist contractor: Menard

02

03

01 - 02 - 03 The two satellite photos (above) were taken three months apart (May and August). The lighter-coloured areas show the progress of the platform, in other words the progress of the ground improvement works.
The Jaber Al Ahmed project is where the roadways are outlined; Northwest Sulibikhat is on the bottom right.

Q&R

Gilles Costa
Director of Menard Middle East

Is Kuwait the new centre of activity in the Middle East?
Kuwait is one of the major oil-producing states, but it has not really been investing since the 1990 war with Iraq. This situation is now changing and there are a lot of infrastructure, port and new town projects in the pipeline that will sustain business activity in the region for the next five to 10 years. The Emirates have been hit hard by the financial crisis, and I'd expect to see the centre of gravity for business in the Middle East move North, to Kuwait, Saudi Arabia and, in the future, Iraq.

01

01 The exhibition spaces are being developed in two levels in a 3,500 m² area over which a luminous glass canopy will "float".
02 Because the work is being carried out immediately adjacent areas where great works of art are on display, noise and vibrations are closely monitored and kept to a minimum at all times.

02

SOLETANCHE BACHY

— Department of the Arts of Islam, Louvre Museum/France

Eighteen months of work without closing to the public

President Jacques Chirac's decision in 2003 to create a department dedicated to the Arts of Islam at the Louvre kicked off the development of a new exhibition space. "Because there was no room anywhere in the museum," said Romain Brieu, the Soletanche Bachy operations manager in charge of the project, "it was decided to create the new space under the Cour Visconti. So construction began with major underpinning, excavation and shielding work." This phase was completed in July 2010, when Soletanche Bachy handed over the 12 m excavation under the courtyard and the 8 m excavation under the Daru wing to Lainé Delau (VINCI Construction France), its partner in Works Package 1. Lainé Delau has since begun the structural work.

To excavate the clean, dry "box" studded with micropile heads across the entire raft, the Soletanche Bachy teams worked "under the noses" – albeit underground and therefore out of sight – of museum-goers visiting the Louvre, which remained open to the public throughout.

A substantial proportion of Soletanche Bachy's special foundation techniques were employed on the project: to start with, 400 jet grouting columns with an average height of 10 m were installed under the original foundations to distribute all loads (facades and interiors) to the solid limestone bedrock under the surface alluvial layer. Next, 200 injection holes were drilled through the jet grouting columns to a depth of up to 22 m, forming a waterproof "skirt" to protect the site from water ingress (the water table lies at a depth of 6 m), along with crack injections designed to consolidate the original foundations. Earthworks then got under way, alternating with anchoring (900 anchors and nails) and wall shielding (3,700 m² of shotcrete). Lastly, 100 micropiles were installed to counteract uplift. "The work was more complex under the Daru wing," said Romain Brieu, "because we had been asked to hand over the space without support pillars and this entailed construction of large beams."

Participants
Client: Direction de la Maîtrise d'Ouvrage du Louvre
Architects: Rudy Ricciotti and Mario Bellini
Works director: Gérard Le Goff
Technical design office: Berim
Museographers: Renaud Pierard and Mario Bellini
Specialised contractor: Soletanche Bachy

Q&R

Romain Brieu
Operations manager, Soletanche Bachy

What major restrictions did you have to contend with on this project?
Throughout the project, we had to be very careful not to allow the existing structures to move, since the displacement tolerances were very tight (3 mm alarm threshold). The worksite was therefore instrumented, using the Cyclops system, by our subsidiary SolData and monitored throughout the works. The other restrictions were related to the narrow access portico, which forced us to disassemble and reassemble machinery or to work with special narrow models. Lastly, the fact that the museum remained open to the public meant that we had to build new emergency exits, because the courtyard exits had been closed off.

Freyssinet supplied and installed 1,000 t of pre-stressed horizontal elements for the complex's five silos.

FREYSSINET

— Al Taweelah aluminium complex/United Arab Emirates

First use of pre-tensioning in the aluminium industry

Lying halfway between Abu Dhabi and Dubai is the aluminium complex of the Emirates Aluminium Company Limited (EMAL) at Al Taweelah. The first phase of construction was completed in February 2010. When fully operational the facility will be the world's largest in terms of capacity, with a projected annual output of 1.4 million tonnes. The works carried out included the construction of massive prestressed concrete structures for storing raw materials: three silos for aluminium oxide (50 m high and 43 m in diameter) and two for coke (also 50 m high but with diameters of 28 m). The project included a first for Indian project management company Petron, itself no stranger to designing aluminium facilities: the use of horizontal pre-stress by post-tensioning that was employed for all five silos. According to Vincent Bernier, head of civil engineering for Freyssinet Middle East, "this technique was chosen as part of a desire to optimise the volumes of materials employed, particularly reinforcing steel and concrete. It demanded tremendous cooperation at the design stage to ensure that our various elements would come together smoothly." The tender won by Freyssinet comprised three components: design, supply (930 t of steel in total) and execution. The execution phase presented no particular technical challenges, "and as everything had been so well planned," adds Vincent Bernier, "we were able to deliver the structures one month ahead of schedule."

Participants

Client: Emirates Aluminium Company Limited (EMAL)
Project management: Petron Emirates Contracting & Manufacturing Co., Ltd
Engineering, construction procurement and management: SNC Lavalin International Inc. and Worley Parsons Engineering Pty Ltd
Specialist contractor: Freyssinet Middle East

01 The main Reinforced Earth® structure on the section under construction totals 6,200 m² and comprises three walls on a 48 m vertical drop.

02 "Gabion" TerraPlus® panels are being used to decorate the downstream retaining wall.

TERRE ARMEE
— A89 motorway/France

Three designs to optimise environmental integration

In the Tarare region of eastern France, work is under way on the West 1 earthworks, engineering structures and communication restoration package of section 9.2 (Violay–Goutte Vignole) of the A89, the new direct motorway link between Lyons and Bordeaux, which is to be opened to traffic in 2012.

This motorway section crosses the Monts du Lyonnais, a range of low mountains to the west of Lyons. VINCI Construction Terrassement asked Terre Armee France to design, supply and assist with the construction of several retaining structures. Two of them have already been completed: the R184, a 1,000 m² structure made of plantable TerraTrel®, and the Chalosset wall at the eastern exit of the tunnel of the same name, a 2,000 m² structure made of TerraPlus® panels (rectangular panels 1.5 m high by 3 m long) with "gabion" facing.

The third structure, known as the Chadier walls, is the most remarkable as it covers a surface area of about 6,200 m² with a 48 m vertical drop. Located near the village of Joux and further west than the other structures, it comprises three superimposed walls on a steep slope where the road has a 4.5 m vertical drop.

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The downstream retaining wall, which is currently being erected, is made of "gabion" TerraPlus® panels. Construction of the lower wall started at the beginning of summer 2010. ASF, the owner, decided in favour of the "ASF" design TerraPlus® facing panel for the intermediate and upstream walls, on which work started in autumn 2010. This design has already been used on a number of its network's retaining structures and has become a kind of "signature".

With a view to reducing earthworks and simplifying construction, Terre Armee's engineers proposed erecting the intermediate Chadier wall along a sloped foundation parallel to the upper paved surface.

Participants
Client: ASF (Autoroutes du Sud de la France)
Project management: Egis
Main contractor: VINCI Construction Terrassement
Specialist contractor: Terre Armee SAS

Q&R

Laurent Hujeux
Works Director, Terre Armee France

Could you describe your installation support work?
We check that all equipment is delivered to the site for the start of work and train the execution crew, which as a rule is made up of earthworks specialists. We stress the issues that require particular attention at the start of works: careful placement of the first row of facing panels and the slight batter (tilt) that must be given to the elements to achieve perfect verticality following backfill and backfill compaction. The main thing to pay attention to when installing Reinforced Earth® structures is that all elements must be free to move and that there must be no hard spots in the structure. Safety is also an important part of the training, because the elements weigh up to 1.8 tonnes. Compliance with a number of rules is therefore essential.

01

01 The full-scale mock-up was used to qualify the tendon insertion, injection and replacement methods.

NUVIA TRAVAUX SPECIAUX

— Jules Horowitz Reactor, Cadarache/France

First unbonded post-tensioning application

With the Osiris reactor built in Saclay in the 1960s scheduled to shut down soon, the French Atomic Energy Commission (CEA) planned a new experimental reactor in Cadarache and began work on it in 2009. The reactor, called the RJH (after Jules Horowitz*), is designed to test new fuels and materials to prepare the next generation of nuclear power stations.

The specifications called for the use of unbonded post-tensioned prestressing in the reactor containment. This was entrusted to Nuvia Travaux Spéciaux along with a number of other missions (which *Resonance* will be reporting on as the project proceeds). "The use of unbonded prestress – the linchpin of the third safety barrier, the reactor containment – is a major move," said Sébastien Diaz, who heads the construction and decommissioning department at Nuvia Travaux Spéciaux (NTS). "This is part of the current drive to lengthen the service life of installations. With this method, prestressing can be measured at any time after it is installed and its elements re-tensioned or for that matter replaced, if need be." Unlike conventional post-tensioning, in which uncoated tendons are directly grouted in the ducts after tensioning, unbonded post-tensioning uses sheathed and greased strands – i.e. protected by an HDPE (high-density polyethylene) sheath and greased on the inside for protection – that can all be accessed at any time after installation, provided a number of changes are made in the anchor design. Another advantage is that their installation accelerates construction since injection operations can be carried out in parallel to other tasks without impacting on the critical path. Before it could be installed in Cadarache, the solution had to be tested and qualified according to the rules applying to all nuclear projects. Client-monitored tests were performed on a full-scale mock-up at the Freyssinet Products Company (FPC) site in Saint Eusèbe. The tests, involving tendon insertion and grease injection, were carried out in July and October, leaving enough time to qualify the system prior to the start of the operational phase scheduled in 2013.

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

Q&R

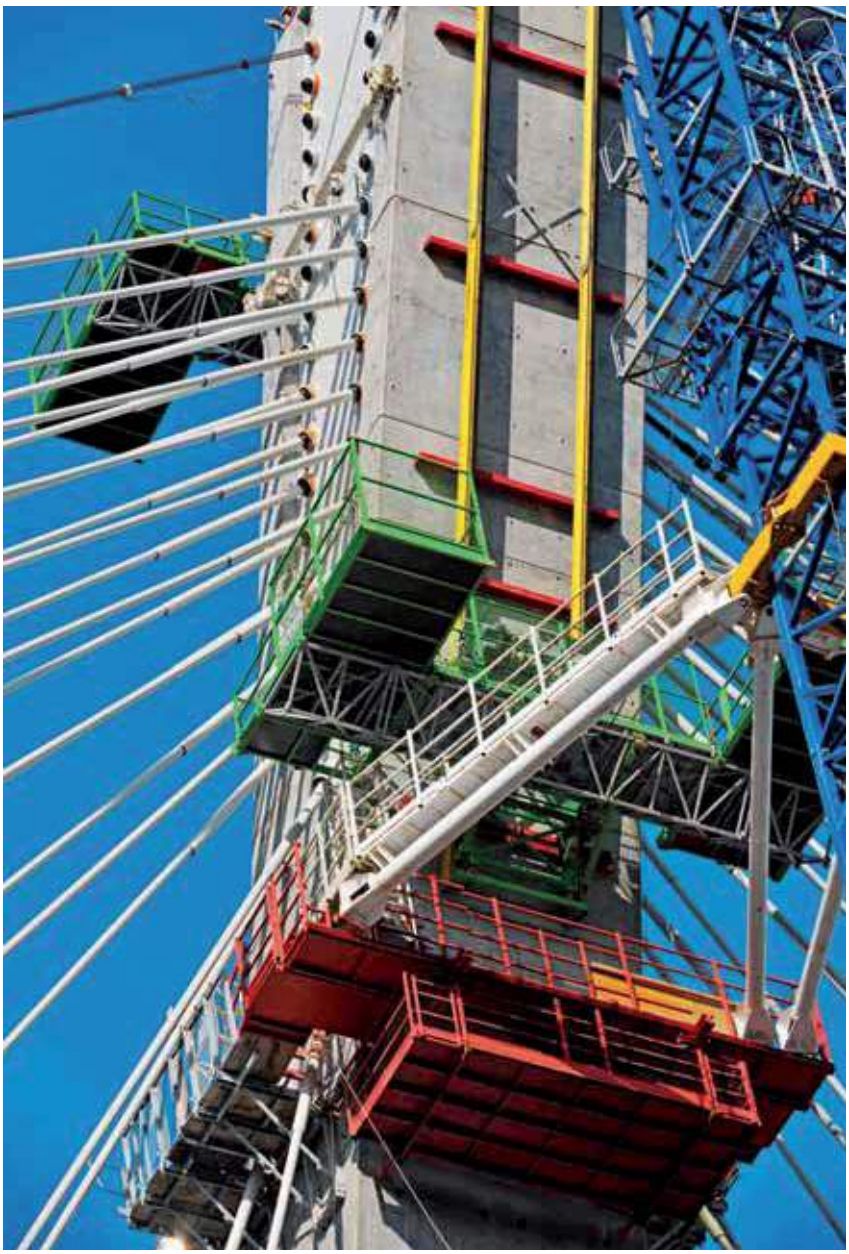
Sébastien Diaz
Head of the construction and decommissioning department, Nuvia Travaux Spéciaux

Why did tendon insertion need to be tested?
In conventional unbonded post-tensioning applications (cable stays, post-tensioned floors) the sheaths are virtually straight. This is not the case here, especially for the horizontal pre-stress, because of pipes and civil engineering features that made major angular deviations necessary. So we had to develop a tool and an insertion procedure that would not damage the tendon sheathing.

Participants
Client: Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA)
Project manager: Areva TA
Specialised contractor: Nuvia Travaux Spéciaux

FREYSSINET/ TERRE ARMEE
— Térénez bridge/France

Combined expertise for a unique new bridge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At 515 m long, the Térénez bridge is not a truly great cable-stayed bridge. However, the solutions employed in the face of the environmental and geological constraints make it one of the most graceful and technically accomplished such bridges. Intended as a replacement for the eponymous suspension bridge built during the 1920s, design work on the new structure started during the late 1990s. Subsequently, the choice of an entirely curved cable-stayed structure led to intensive research into tower designs and stay configurations to enable a constant carriageway width of 7.5 x 4.9 m as well as allowing the towers, which are curved in plan, to be inclined forwards to allow for the curved structure. After looking at some 30 different configurations, the final decision was made to employ the lambda-shaped towers (λ) that define the structure.

After pressure grouting the north bank in late June 2010, it only remained for the constructors' joint venture entity to complete the final offset pedestrian segments of the deck, a task completed in August. Freyssinet site engineer Ronan Bohéas explains that "for Freyssinet, which supervised the project with Mathieu Lemoine (head of production) right up until April 2010, this meant installing and tensioning 40 stays (i.e. 10 four-day cycles), reaching the pre-load required on the underside of the deck and then carrying out the final lifting operation, which in this case was dismantling the mobile machinery." Not a lot if you consider that since 2007 the company has been heavily involved in the design, supply and fitting of the 144 stays (300 t) and the pre-tensioning (146 t). For the towers, Freyssinet was involved in three separate areas. First, the horizontal anchors tying the two legs together at the foundation footing. Then, two elements of vertical tensioning, both permanent (six cables) and temporary (eight cables), the temporary tension being installed to compensate for the absence of stays during construction of the deck. Ronan Bohéas adds: "There are two further 130 m retaining stays fitted between the abutment and the tower head. These are intended to limit the stresses at the base of the towers caused during the construction phase by the non-symmetrical nature of the central span." Freyssinet's lifting prowess (using Hebetec jacks) was also put to good use on 16 occasions in order to set up and remove the mobile machinery. Lastly, the Freyssinet brand also leaves its mark via the 40 internal hydraulic dampers fitted to the stays and the twin lines of Multiflex S250 expansion joints used in the abutments.

Participants
Client and project manager: Conseil Général du Finistère
Construction consortium: Dodin Campenon Bernard, GTM Bretagne, Sogea Bretagne, Freyssinet

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Q&R

Ronan Bohéas
Site engineer, Freyssinet

What made this project special?
This is a highly technical structure that required permanent attention because the structure itself was subject to great stresses during construction, meaning that loads had to be restricted and their distribution carefully calculated. This creates a very demanding environment: there is limited space on the deck and the cycles for creating the offset sections are very short. There is a great spirit of cooperation among the crews, helped by the knowledge that we are building an exceptional structure.

Reinforced Earth® triple retaining wall

Cramps and abutments. These were the object of as much special care during the design phase as every other part of the structure.
Built in Reinforced Earth® elements, they stand out thanks to the unusual association of three separate retaining wall systems, up to a height of around 15 m: TerraTrel® at the base, angled and landscaped; vertical mineral TerraTrel® for the second tier, and, finally, a TerraSet® retaining wall whose large upper lips form a safety rail. Totalling 2,200 m^2, these structures were completed in October 2007 on the south bank, and in January 2008 on the northern side.

01 72 stays (2 x 36) are anchored to each tower head; they vary in length from 35 to 149 m.
02 to 04 - 07 Carried out as a JV by Freyssinet France Nantes agency and the major projects division, the company's contributions to the project involved some 20 staff.
05 Reinforced Earth® access ramp and northern abutment.
06 A special feature of the structure is the wholly curved deck.

01

01 In a decade or so, CSM Bessac has built nearly 30 km of sewer outfall pipes in the Colombian capital.
02 After pioneering trenchless tunnelling in Colombia, CSM Bessac set up Bessac Andina, a subsidiary specialising in micro-tunnelling, in 2008.

SOLETANCHE BACHY
— Tunjuelo Bajo Interceptor in Bogotá/Colombia

Completion of a third one-off project and birth of a subsidiary

All good things come in threes. After winning two design-build sewer collector projects using tunnel boring machines that were completed in mid-2002(1) and early 2010(2), the Soletanche Bachy Cimas-CSM Bessac partnership won a similar(3) contract in 2008, which is scheduled for handover at the end of 2010. "Similar – but not identical," said Bernard Théron, director of Soletanche Bachy specialised subsidiary CSM Bessac. "In 2000, we introduced urban TBM works in a country where such operations had never before been carried out. The first two projects were a spectacular success and we identified a potential market – especially for small-diameter works – in the region. This convinced us that we could develop a long-term business activity here alongside the major one-off projects." When the third contract came in, the local entity and the specialised subsidiary therefore set up a joint subsidiary, Bessac Andina, which specialises in micro-tunnelling (0.50 to 2 m diameter) operations. It is headed by Juan Fernando Uribe, who is also CEO of Soletanche Bachy Cimas.

The idea proved to be a good one. No sooner had it been set up than the new company bid on an 800 m long, 1,600 mm diameter collector running under the Autopista Norte in Bogotá. At the same time, it is building a 2.5 km tunnel initially designed as a cut-and-cover on the Tunjuelo Bajo Interceptor – a major project calling for tried and true expertise, providing the new subsidiary with an ideal opportunity to earn its spurs and prove itself. At the same time, the company undertook a communication campaign to publicise the technique beyond Bogotá.

As the subsidiary completed its first contracts after less than two years of existence, Bernard Théron was very positive in his assessment of its track record. "On our first project – the Autopista Norte – we came in within deadline and budget, we immediately moved on to new projects, and engineering studies are under way for projects in Medellín, Cartagena and Cali. In fact we turned out to be more successful than we had hoped. In 2010 our revenue forecast exceeds €10 million, far above what we expected."

(1) – Rio Bogotá Interceptor
(10 km; 2.20 and 2.75 m diameters; €35 million)
(2) – Fucha Tunjuelo Interceptor
(9.5 km; 3.75 m diameter; €55 million)
(3) – Tunjuelo Bajo Interceptor
(10 km; 1.60, 2.45 and 2.75 m diameters; €50 million)

Participants
Client: Empresa de Acueducto y Alcantarillado de Bogotá
Project managers: Estudios Tecnicos, IPC and CEI
Contractor consortium: CSM Bessac, Soletanche Bachy Cimas, ConConcreto

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TERRE ARMEE

— Mine extension in Yandi/Australia

Added-value solution using Reinforced Earth® and TechSpan® arches

To enable it to boost its annual iron ore production by 50 million tonnes, to 205 million tonnes, BHP Billiton, one of the world's top three mineral extraction companies, decided to fit its Yandi mine in the north of Western Australia with a new conveyor tunnel-silo. The installation forms the base of a 24 m high iron ore waste heap and comprises an 11 m high rectangular silo with two tunnels that lead off in either direction. The tunnels are fitted with conveyor belts that allow material to be transported from the heap for processing or transport.

BHP Billiton and its design and management consultant Fast Joint Venture wanted to build the silo using Reinforced Earth®, a solution that is more cost effective, faster and easier to use than poured reinforced concrete walls in a remote area like Yandi.

After being contacted about the project feasibility, particularly in relation to the deflections likely to occur in the wall as a result of the variable load exerted by the heap, Reinforced Earth Company Pty Ltd (RECo) Australia took the view that these deflections were within allowable limits and that it was possible to design a Reinforced Earth® solution to resist the loadings. In June 2009, having won the contract for validating the design, provision and assistance in the erecting of the pre-fabricated silo walls (TerraPlus® elements) and the TechSpan® arches for the conveyor tunnels, RECo Australia commissioned a 3-D analysis of the finished elements as well as performing scaling calculations with the aim of limiting wall deflections to not more than 30 mm. Manufactured in Perth, 1,350 km south of Yandi, the elements were trucked up to the site.

As part of the same project, RECo Australia also won an order from Laing O'Rourke for the design and supply of the constituents for two large TerraMet® walls (4,000 m2) for crude ore crushers. The TerraMet® solution is traditionally used for this type of application because of its low weight, high performance and low transport costs.

RECo Australia provided full-time assistance to the build teams on both these projects during the period late 2009-early 2010.

01 The large walls surrounding the crude ore crushers use TerraMet® retaining systems.
02 The remote nature of the site led BHP Billiton to innovate by building its new conveyor silo-tunnel complex using Reinforced Earth® with TechSpan® arches.

Participants

Client: BHP Billiton
Project manager: Fast JV/Laing O'Rourke
Main contractor: Thiess
Specialist contractor:
Reinforced Earth Pty Ltd (Australia)

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01 Menard used CMC to reinforce the ground for the foundations of 103 of the farm's 240 wind turbines.

MENARD

— Fantanele wind farm/Romania

A wind farm dotted with CMC

CMC are already a proven solution to improve the bearing capacity of poor ground under static loads. Demonsdtrating that this technology is also a real alternative to piles for supporting dynamic loads was another challenge that the engineers at Menard were keen to meet. The first application for approval we made received a positive answer from an inspection agency in 2007, for the Hombleux wind farm in France. We then completed further projects in France and elsewhere," explains Cyril Plomteux, Menard's regional manager for Europe.

The CMC solution is a very prominent feature of the wind farm at Fantanele, close to Constanta on Romania's Black Sea coast. When completed the farm will host a total of 240 2.5 MW wind turbines, making it Europe's largest onshore installation. Following a winter break, Menard completed soil improvement works for an initial package of 139 turbines, using CMC in 103 cases. "The ground where we are working is loess, comprising 65% silt, 20% chalk and 15% sand. For each turbine, 105 CMCs were installed," he continues, "at depths of 5 to 25 m, following variable grid patterns from the centre to the outer edge of the concrete structure supporting the turbines."

Participants

Client: CEZ
Project manager: Continental Wind Partners (CWP)
Main contractor: joint venture between Viarom Construct (civil engineering) and Energobit (electrical)
Specialist contractor: Menard

Q&R

Cyril Plomteux
Regional manager for Europe, Menard

In theoretical terms, how do you engineer a ground improvement solution for wind turbine foundations?
In order to design a CMC network beneath wind turbines it is necessary to create 2- and 3-D models based on the ground characteristics and the various potential loads. Through modeling, we can check that the technical specifications are respected in terms of the load-bearing capacity and stability of the overall wind turbine structure. A transition layer of variable thickness is installed between the lower face of the footing and the top of the inclusions. It attenuates the horizontal shear stress so that the columns only support a uniaxial load.

01

01 - 02 - 04 The skilled workers who participated in the construction of the Bay Chai Bridge in 2005 met up again on the Phu My project in 2008.
03 Phu My Bridge, a key link in the new urban ring road, provides an additional route towards the port area.

02

03

FREYSSINET
— Phu My Bridge/Vietnam

Four stay cables and two sections of deck every five days – a record in efficiency

With almost 6.4% growth projected in 2010, Vietnam is one of the most dynamic countries in Asia, and its boom is particularly noticeable around major urban centres. As part of a programme stretching over more than 20 years, Ho Chi Minh City, formerly known as Saigon, is being extended and its port moved further south. Modern residential districts have replaced vast swamps and are now connected by a ring road in the south-east sector of the city. The Phu My Bridge, opened in September 2009, is part of that ring road. It links the second and seventh districts over the River Saigon and helps to alleviate the heavy goods vehicle traffic, for which the only other crossing towards the port is a bridge further upstream, in a densely populated area of the city.

The project was carried out under a 30-year concession contract awarded by the government to Phu My Bridge Corporation (PMC). It was Vietnam's first road structure concession contract and was put together with the help of Freyssinet's major projects department. The construction consortium for the main bridge, Bilfinger Berger-Baulderstone Hornibrook (BBBH), asked Freyssinet to supply and install the prestress for the towers and deck, 144 stay cables (type H2000) and Internal Hydraulic Damper and Internal Radial Damper stay cable dampers. The civil engineering works were launched at the beginning of 2007 and Freyssinet's teams arrived on site in July 2008. "The small team of expatriates, led by Alain Granet, met up with the experienced skilled workers who had participated in the construction of the Bay Chai Bridge in Along Bay in 2005," says Mathieu Lemoine. He was a trainee back then but returned to Vietnam as technical manager in charge of stay cable installation having completed his Ponts & Chaussées engineering degree.

As at Bay Chai, the stay cables at Phu My were installed simultaneously with the deck construction. The deck was cantilevered by 10 m section, poured in situ, with the aid of a mobile rig (except for the first components located to the right of the towers), each section being fitted with prefabricated stay cable anchor chambers. Freyssinet's services also included raising and lowering (14 in all) the mobile rigs, each weighing in at about 300 t, as well as the pier segments (1,200 t including the formwork).

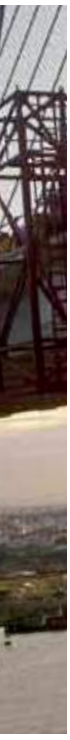
"The most remarkable thing about this project was the speed at which it was executed," continues Mathieu Lemoine. "An entire cycle – setting up the mobile rig, installing the prefabricated components and reinforcements, connecting the prefabricated chamber, initial tensioning of the stay cables, concreting and final tensioning of the stay cables – took just five days." This pace was kept up throughout the project, enabling the last stay cable to be installed on 19 May 2009, four months ahead of schedule.

Key figures

Bridge length (including approach viaducts): 2,032 m
Main bridge length: 705 m
Width: 27 m (two-lane dual carriageway for cars, two single lanes for bicycles and motorbikes, two single lanes for pedestrians)
Tower height: 134.5 m above the foundation pile caps
Clearance below the deck: 45 m
Prestressing: 290 t
Stay cables:
1,000 t (26 to 80 strands)

Participants

Client: PMC (Phu My Bridge Corporation)
Project management: Maunsell (Australia)
Construction consortium: BBBH (Bilfinger Berger-Baulderstone Hornibrook)
Engineering: Arcadis (France) for the main bridge; Cardno (Australia) for the approaches
Specialist contractor: Freyssinet



Q&R

Mathieu Lemoine
Production manager, Freyssinet

What safety measures were taken on the project?
"Under the terms of the contract, the construction consortium had to comply with a number of requirements, such as marking access routes and checking railings daily, and using a sticker system to confirm this work had been done. In addition, BBBH organised a monthly safety award for the team that had achieved the best safety performance or stood out from the rest by virtue of the special efforts it had made. Freyssinet joined in with these measures while continuing to apply its own approach: daily briefing sessions, instructions on wearing personal protective equipment, etc. The message was passed on in Vietnamese by a supervisor. And it was received loud and clear because the 40 local employees of the companies operating on the site had worked on Freyssinet projects before and were well trained in its techniques and safety policy rules."

04

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SOLETANCHE BACHY

— Liefkenshoek rail link, Antwerp/Belgium

The project moves to the right bank

While tunnel boring machines Schanulleke and Wiske continue to wend their way under the River Escaut, Soletanche Bachy's and Fontec's teams, who moved to the right bank at the end of 2009, have started work on KW* 11 and 12, two of the remaining three civil engineering works packages for the Liefkenshoek rail link *(see opposite)*. "These cover the TBM arrival shaft (KW11), where the first machine is expected in July and the other in September 2011, and foundations for engineering structures and for cut-and-cover walls, which are the final components of the link to the Antwerp North marshalling yard," says Marc Van den Eynde, Fontec's project manager. The work yet to be done, 40,000 m^2 of temporary slurry cut-off walls and 35,000 m^2 of diaphragm walls (out of a total of 200,000 m^2 and 120,000 m^2 respectively), is not very different from that completed on the left bank, but the execution conditions are nothing like the same. The geology, for instance, is different: the clay layer in which the cut-off wall is anchored is more than 50 m below the surface (instead of about 20 m to 30 m on the left bank), which needed three rigs operating in two workstations during the preparatory works phase. Other constraints on works package KW 11 include the geometry and narrowness of the site, together with the short deadline – all the civil engineering is to be delivered in 2013. "The various tasks to be completed – foundations, civil engineering for the roof slabs and top-down excavations – mean there is no idle time," explains Marc Van den Eynde. "As a result, there has to be constant communication at main contractor level and a great many precautions have to be taken to avoid the risks associated with multiple activities going on at the same time, particularly mixer-truck traffic and the supply of reinforcement cages in a restricted space." Because of the high number of factories around the site, the road network is dense and has many crossings. There are also overhead high-voltage lines and buried systems, not all of which could be re-routed. Uncompromising safety procedures will have to be implemented on KW 12, for instance, where there is a gas mains that supplies a number of factories in the neighbourhood.

** Abbreviation of Kunstwerk, the Dutch word for "engineering structure".*

Participants
Concession grantor: Infrabel
Concession holder: Locorail
Works consortium: Locobouw
Specialist contractor: Soletanche Bachy

01 Although the volume of work that remains to be carried out on the right bank is less than that on the left bank, its execution is more difficult due to the geological conditions and the narrowness of the site.

A major project under concession

The Liefkenshœk rail link is 16 km long and includes a 6.5 km tunnel. From mid-2014, it will provide a direct link between the port facilities on the left bank of the Port of Antwerp and the main railway station, located on the right bank of the Escaut. Infrabel awarded the concession to project company Locorail (comprising CFE SA, VINCI Concessions and BAM PPP Investments Belgium). The project is being built by Locobouw, the construction consortium, which will also maintain the infrastructure for 38 years.

01

01 Eight rigs equipped with V23 vibroflots installed the stone columns, which was the most technical component of the project.
02 The stone columns are sunk to depths of 3 m to 6 m.

02

SOLETANCHE BACHY

— Muscat Airport/Oman

Ground consolidation for a new runway

In 2006, the authority in charge of Muscat International Airport launched a project to build a new runway and taxiways to meet the growth in traffic. However, 25% of the surface on which these facilities are to be built is typical of a *sabkha* region. "The terrain is made up of silt, clay, organic deposits and loose sand. This forms a layer about 5 m thick, which can be subject to liquefaction or significant subsidence. As a result, it is not suitable for the construction of an airport runway or taxiways without prior ground improvement," explains Yvan Mabed, the Soletanche Bachy works engineer who is project manager.

The works were awarded to Soletanche Bachy as main contractor and have been progressing at an intensive pace – 24 hours a day, six days a week – since the start of the project in June 2009. They involve consolidating the ground using the dry method of installing stone columns down to a depth of between 3 m and 6 m. In addition, about 330,000 m^3 of organic material has had to be replaced by granular material, which is then consolidated by installing the stone columns. "Once the columns are in place, the permanent backfill and preload material help to reduce settlement over the long term to very low values," adds Yvan Mabed.

In all, 81,000 stone columns have been installed over an area of 365,000 m^2. The project required up to eight rigs using V23 vibroflots manufactured by Soletanche Bachy and operated by 160 people – 350 if the subcontractors in charge of earthworks (2.5 million m^3), dewatering and boreholes are included.

"Throughout the project, Soletanche Bachy has also been in charge of geotechnical investigations and cone penetration testing."

Participants

Client: Ministry of Transport and Communications, Oman
Client-side project management: ADPi (Aéroports de Paris International)
Consultant engineer: Cowi-Larsen Joint Venture
Main contractor: Soletanche Bachy, Oman Branch LLC; earthworks subcontractor: Al Sarooj LLC

01

01 Short boom equipment is used on the diaphragm wall sections located under motorway viaducts.
02 The future four-level Express Rail Link terminus will be developed in a 12 hectare area.

SOLETANCHE BACHY

— Express Rail Link/ Hong Kong

Thirty-two foundation equipment rigs for the gigantic terminus

02

In the early 2000s, Hong Kong undertook a major rail infrastructure construction programme, which is set to continue until 2015. The Express Rail Link (XRL), one of the key projects, involves the construction of a 26 km tunnel section from West Kowloon to the Hong Kong-Shenzhen border. It will be part of the Guangzhou-Shenzhen-Hong Kong Express Rail Link and will connect with the 16,000 km national high-speed rail network spanning continental China. The project was approved by the Hong Kong Legislative Council in January 2010 and work got under way immediately.

One of the main operations is the construction of the underground West Kowloon Terminus (WKT), the end of the line at the western tip of the Kowloon peninsula. The triangular-shaped structure covers 12 hectares. It will be built on four underground levels, comprising the underground rail lines, with nine platforms for mainline trains and six for local trains; departure and arrival halls; administrative premises for the customs and immigration services; car parks and shops. "Some 10 works packages have already been awarded," said project director Frédéric Hubert. "Soletanche Bachy's Hong Kong subsidiary Bachy Soletanche Group Ltd won three of them under direct contracts with MTR Corporation: 100% of 803 A and 803 D, and the 811 A package in a joint venture."

Works package 803 A involves the construction of the lateral diaphragm walls, with a length of 900 m and a depth of 25 to 50 m, in addition to a bypass road that comprises six major intersections and a temporary bridge. Works package 803 D covers the diaphragm wall facing the sea – 530 m long and 24 to 55 m in depth – as well as a 60 m temporary slurry wall, 177 cast-in-place piles (3 m diameter) and 890 piles (0.61 m diameter) with internal reinforcing beams. Works package 811 A involves 200 m of cut and cover linking the two rail tunnels with the approach section to the terminus. "The difficulty in this works package," said Frédéric Hubert, "is the fact that a metro line runs through the middle of the excavation zone and will continue to operate throughout construction. Monitoring will therefore be a major focus, to prevent any negative impact on existing tracks."

Lastly, Bachy Soletanche Group Ltd will also be building two ramps to allow removal by barge of the 4.7 million m^3 of spoil generated by the WKT project. At the worksite, 13 diaphragm wall rigs, 19 pile rigs and the civil engineering teams have started work, pending the award of further works packages.

Participants

Client: Government of the Hong Kong Special Administrative Region
Project manager: MTR Corporation
Contractor: Bachy Soletanche Ltd

01

FREYSSINET
— GL2K Complex in Skikda/Algeria

Showcase project in a country undergoing strong development

In January 2004, an accident destroyed three of the six natural gas liquefaction trains at the gas terminal in the Port of Skikda in north-eastern Algeria. Six years later, a new complex, GL2K, is being built on the site. Sonatrach, the state-owned company in charge of production, transformation and commercialisation of hydrocarbons, awarded the construction to US firm KBR (formerly Kellogg Brown & Root), one of the leading players in the sector.

The plant, which will be the country's biggest gas complex, will be supplied by the Hassi R'Mel gas field. It will have an annual production capacity of 4.5 million tonnes, and will also produce propane, butane, ethane, gasoline, etc. The consortium formed by VINCI Construction Grands Projets with Entrepose Contracting, its subsidiary Entrepose Algérie and Orascom, won the design and civil engineering works packages in 2008. The consortium then awarded Freyssinet the design, supply and assistance with implementation of the prestressing of a 150,000 m^3 liquefied natural gas (LNG) tank, together with two 66,200 m^3 tanks, one for butane and the other for propane.

"The works started in March 2009," says Abdelrani Mohri, works manager for Freyssinet International & Cie, "and are being carried out simultaneously on all three structures." The first step was to install the horizontal and vertical prestress sheaths. This was followed in September 2010 by the company starting to thread in the cables – 1,000 tonnes in total. These will be post-tensioned and then injected with grout after the last ring of the tanks has been concreted.

Participants

Client: Sonatrach (Société Nationale pour la Recherche, la Production, le Transport, la Transformation et la Commercialisation des Hydrocarbures)
Project management: KBR (formerly Kellogg Brown & Root)
Works: consortium comprising VINCI Construction Grands Projets, Entrepose Contracting, Entrepose Algérie and Orascom Specialist contractor: Freyssinet International Cie (design, supply and assistance with implementation)

02

01-02 Prestressing of the three structures cannot be completed until after the domes have been raised and concreted.

Q&R

Abdelrani Mohri
Works manager, Freyssinet

Is participating in this project important to Freyssinet in Algeria?
Yes, because Algeria is virgin territory. The country is developing its infrastructure and facilities strongly, and many foreign companies are returning to invest. This project is a first for us and a very important client reference. We hope to be able to use it in our future tender proposals to help increase our business. Freyssinet already has a good reputation here based on the numerous applications of prestressing on bridges and dams since the 1950s.

01

01 The structure was built in the immediate vicinity of the railway embankment slope and only needed to be slid into place.

FREYSSINET
— Morigny-Champigny railway bridge/France

Installation in 12.5 hours

On 5 and 6 June, at Morigny-Champigny (near Paris), Freyssinet France SCCM completed the fourth of 11 engineering structure sliding projects in its 2010 order book. "We set up a 14 m wide railway bridge in the embankment slope of the Paris–Bordeaux line, doubling an old stone structure with only one track, which no longer gave enough access to the Etampes industrial zone," says Remi Laffont, works engineer, Freyssinet. As with other projects of this kind, the structure was built in the immediate vicinity of its permanent location and on a guide raft whose cable boxes included the four 51T15 cables used for manoeuvring. The Autofonçage® technique was chosen because the excavation could only be kept open for a short period due to the proximity of the existing structure. "We could only slide forward a short distance at a time, between 1 m and 1.5 m, because the ground we were working on was sandy and not very stable around the edge of the excavation," points out Remi Laffont. But the friable nature of the ground was a plus for the earthworks (6,500 m^3), which were completed an hour and a half ahead of schedule, giving the green light for the sliding. The four 1,000t jacks started their work at 14.30 and stopped at 03.00 having covered a distance of 41.20 m at an average speed of 3.05 m per hour. The earthworks units moved in straight away to take care of the backfill, and the Colas Rail teams put the tracks back in place. The project was delivered at 10.40 on Sunday morning instead of noon.

Participants
Client: Réseau Ferré de France
Project management: SNCF
Civil engineering contractor: BEC
Specialist contractor: Freyssinet

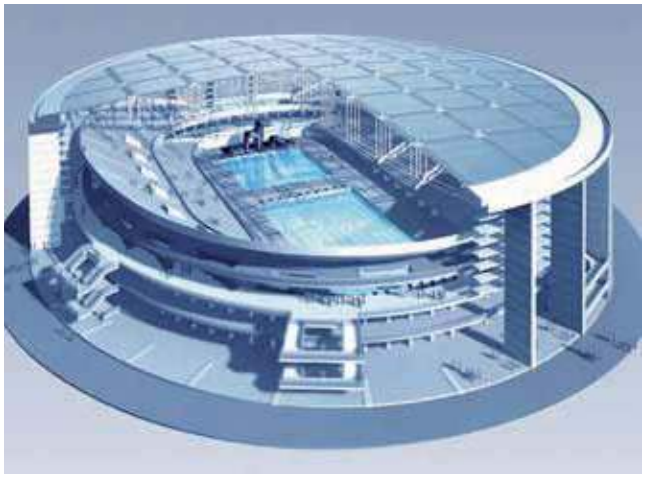
Q&R

Remi Laffont
Works engineer, Freyssinet

Does the quality of the ground influence the choice of technical solution?
Not when choosing between Autoripage® and Autofonçage® because the structure's weight is distributed over the entire footing. This means that both techniques are suitable for use on any type of ground and installation speeds can reach 8-10 m an hour when conditions are good.
We tend to select Autoripage® by default. But if we cannot dig the excavations wide enough due to the proximity of another structure, as was the case at Morigny-Champigny, or when there isn't enough space for spoil storage, we prefer Autofonçage®. However, when the ground has strong bearing capacity, we propose a different method altogether: the AirPad transport System (APS). Its primary advantage is cost in that it enables structures to be built on supports rather than a footing and there is no need to build a guide raft.

01

02



03

01 Following installation of the masts, the outline of the future roof is apparent.
02 In the preliminary phase, the mast support collars had to be very precisely positioned on the cables.
03 A computer-generated image of the structure.

FREYSSINET

— Dr S. P. Mukherjee swimming stadium in New Delhi/India

A frame using Cohestrand® cables

In the run-up to the Commonwealth Games held in October 2010, the City of New Delhi comprehensively renovated and upgraded the Dr S.P. Mukherjee stadium, built in 1982, where the swimming competitions were held. Of the original building, only the structures of the two swimming pools (warm-up and diving, and the Olympic-sized pool) and the overarching 160 m long, 11 m high elliptical concrete envelope were kept. In a new addition, this envelope now supports a roof designed by the German Schlaich Bergermann & Partner structural engineering firm. The complex roof consists of a metal structure covered with a synthetic material, the whole resting on 208 masts of varying geometry to accommodate the positions of the cables and collars. These masts are supported by 60 cross-meshed Cohestrand® cables. "Each mast is connected top and bottom at the cable intersections, which are anchored by a collar system," said civil construction manager Stéphane Marrec, who oversaw the Freyssinet project between September 2009 and handover in March 2010.

Freyssinet was responsible for designing and supplying the cable stays and connection systems as well as installing the entire bearing structure (stays, collars and masts). The company had to anticipate the risks inherent in building a structure made up of elements that will all be subjected to major stresses when it is finished and that had to withstand even greater stresses during construction. Anticipation and precision were also the rule during the execution phase when it came to identifying the exact locations on the cables where crews were to install the collars and calculating the length and tension to be applied to the cables during installation, since it would be impossible to adjust the tension once the masts were in place.

The other major challenge for all those involved in the work was to ensure satisfactory safety conditions during project execution.

Q&R

Stéphane Marrec
Civil construction manager, Freyssinet

Why did you choose to use Cohestrand® cable?
It was the obvious choice. This is the kind of application for which it was designed – to offset lateral forces. In contrast to cable-stayed bridges, stresses here are applied "over" the cable bundles. Another difference lies in the fact that the forces are offset by two sets of perpendicular crossed cables held together by a cast-iron collar specially designed by Freyssinet for this application.

Participants
Client: Central Public Works Department Commonwealth Games Division
Designer: Schlaich Bergermann & Partner
Main contractor: Ahluwalia Contracts (India) Ltd
Specialised contractor: Freyssinet

01

01 Lined with a diaphragm wall to a depth of 45 m, the shafts are then built by conventional methods.

02

Q&R

Salvador Martinez
Quality manager, Cimesa

Could you describe the repair work on Shaft 13?
With the agreement of the client, we decided to cast a watertight cap under water to complete the civil engineering work. In this operation, divers *(photo 02)* first removed the worksite installations and the sand brought in by the water from the bottom of the shaft. The reinforcing armature was assembled on the surface so that it could be lowered in one piece. A concrete was specially formulated that would not be washed out during the casting operation under 13 m of water. A total of 500 m^3 of concrete was needed to carry out the repairs. We began pumping operations five days after they were completed.

SOLETANCHE BACHY
— TEO shafts in Mexico City/Mexico

Six deep shafts for a giant outfall

To appreciate the scale of the TEO (Tunel Emisor Oriente) project currently under way in Mexico City, it must be remembered that no watercourse runs through the city, which is built on former lakebeds. Since water cannot flow out naturally, special wastewater drainage systems are needed. One of the main facilities is an underground outfall tunnel that channels water to the Requena River 60 km north of the capital. Built some 40 years ago and never maintained, its vault is threatening to collapse, which could lead to catastrophic flooding. In an effort to avert this danger and to stimulate the economy through a programme of public works, the Mexican authorities decided to build a new outfall.

The project, awarded to Mexican companies, will cost nearly a billion dollars. Six tunnel boring machines will be used to build a 60 km tunnel at a depth ranging from 40 to 150 m that will end at a site where Latin America's largest wastewater treatment plant will later be built. Carso, a leading Mexican building and civil engineering company that won one of the project contracts, awarded to Cimesa (Soletanche Bachy) the contract to sink six of the 24 vertical shafts required, with diameters ranging from 12 to 20 m. Two of the six will be used to lower and remove the TBMs. "All the structures on which we are working are located outside the city," said Cimesa works director Alexis Behaghel. "The same method will be used to sink all the shafts: a 1 m thick circular diaphragm wall to a depth of 45 m, followed by conventional excavation (earthworks, precast segments, construction of a fibre reinforced shotcrete wall) in 1 m increments to the final depth."

Since the soil consists of alternating layers of sand, clay and loam the diaphragm walls could be built with good vertical tolerance using a KS hydraulic bucket, but during the conventional works that followed there were a number of surprises. Beyond the 50 m depth, work was carried out below the water table and this meant that pumping systems had to be installed and the system monitored at all times to forestall breakdowns. Pumping capacity, averaging 50 to 350 m^3/hour, had to be boosted in Shaft 14, begun in mid-June, to between 1,500 and 2,000 m^3/hour. Moreover, in Shaft 11, the team encountered a 10 m thick layer of basalt at a depth of 62 m, which required the use of a hydraulic rock breaker. "This was not unforeseen, because soundings had detected it. But we did have an unexpected problem in Shaft 13," said Alexis Behaghel, "where high-pressure water ingress at a depth of 93 m opened a fault in the bottom of the shaft and submerged it in 13 m of water, which caused a delay. For this reason, Shafts 11, 13 and 14 remain to be completed."

Participants

Client: Conagua (Comision Nacional del Agua)
Works consortium: Comissa (Constructora Mexicana de Infraestructura Subterránea, SA)
Subcontractor for Shafts 10 to 15: Cimesa (Soletanche Bachy)

FREYSSINET
— Indian River Inlet Bridge/ United States

A new strength for Freyssinet stay cables on the other side of the pond

A few kilometres north of Bethany Beach on the Delaware coast, the H-shaped towers of the bridge under construction soar over the short channel between the Indian River inlet and the Atlantic and the existing bridge built on steel piles. "The old bridge is to be replaced due to the scouring* of its submerged foundations and corrosion – two factors that influenced the specifications of the new project issued by the Delaware Department of Transportation as a design-build tender in 2008. They explain the construction requirements of the new structure: towers to be erected on the banks of the inlet and the use of Freyssinet stay cables, whose 100-year lifespan was a key factor in the client's award decision and thus in the main contractor's choice," says Fabien Tesson, works engineer at Freyssinet and project manager.

The new bridge is 530 m long in total, with a deck of 290 m. It has two traffic lanes in each direction and its concrete deck is supported by 152 cables in two stay planes. As the bridge is low (vertical clearance of no more than 4.30 m above water level) and over half its length is accessible from the ground, most of the deck can be built on shoring, thereby limiting the use of the mobile rig to the central span only. The cables are covered by a co-extruded HDPE sheath in pale blue – a new colour – and installed as the construction advances. Work on the deck and stay cable installation started in spring 2010 after completion of the towers. It should be finished at the beginning of 2011, with a view to opening the new bridge to traffic in July.

** Erosion of a structure's foundations by water movement.*

Participants
Client and project manager: Delaware Department of Transportation (Deldot)
Design: Aecom
Main contractor: Skanska
Specialist contractor: FIC (major projects department) in association with Freyssinet Inc.

01

01 The new bridge's deck is built initially on shoring and the stay cables are installed as the construction progresses.

Q&R

Andrew Micklus
Chief operating officer commercial & technical, Freyssinet Inc.

What impact did the Buy American Act have for Freyssinet on this project?
Under that Act, all steel products used in federally funded projects must be 100% US manufactured. It therefore requires a contractor to have a network of approved local suppliers and to carry out technology transfers. Freyssinet did all this in 2004 when it built the Arthur Ravenel Jr. Bridge in South Carolina.

That said, for the semi-bonded strand patented by Freyssinet, the supplier can only provide us with the bare strand. The semi-bonding is carried out through an exclusive anti-corrosion and polymer extrusion process internally in the United States. This technology know-how is a genuine strength because a large number of potential applications are emerging today on the American market.

01 - 02 Nicholson carried out the work from a platform created along the entire length of the curtain to be installed, i.e. 137 m.
03 Emergency repair work was required to halt the seepage observed through the dam's right abutment following heavy rain at the beginning of 2009.

01

SOLETANCHE BACHY
— Howard Hanson Dam/United States

Emergency consolidation before the rainy season

Built in 1962 on Green River in the western part of Washington State, the Howard Hanson Dam is an earthen embankment structure 72 m high and 206 m long. Seepage had been observed through the right abutment, made of rock and earth, ever since the dam was brought into operation in 1961. Monitored carefully by the US Army Corps of Engineers (USACE), which owns the structure, the seepage was controlled for the most part by ad hoc repair work. In January 2009, following torrential rain that filled the reservoir beyond its normal level, USACE deemed the structure to have become dangerous and decided to carry out emergency work before the rainy season started again in November.

The contract for the installation of a grout curtain was won by Nicholson Construction (Soletanche Bachy) in July and the project was started immediately with significant earthworks to develop a safe working platform for personnel. The works themselves consisted of installing a grout curtain over two 137 m lines in the right abutment. This required sinking 480 boreholes to depths varying from 27 m to 52 m (a total of about 16,000 m in the superficial layer and 2,000 m in the rocky substrate, i.e. 2,217 m^3 of injection grout).

Within the limited range of techniques authorised by USACE for sinking boreholes in earthen dams, Nicholson Construction decided in favour of sonic drilling because of its low environmental impact and high productivity. In practice, difficulties associated with the actual execution conditions prevented the use of the injection technique stipulated in the contract, which meant that an additional two drilling machines were needed.

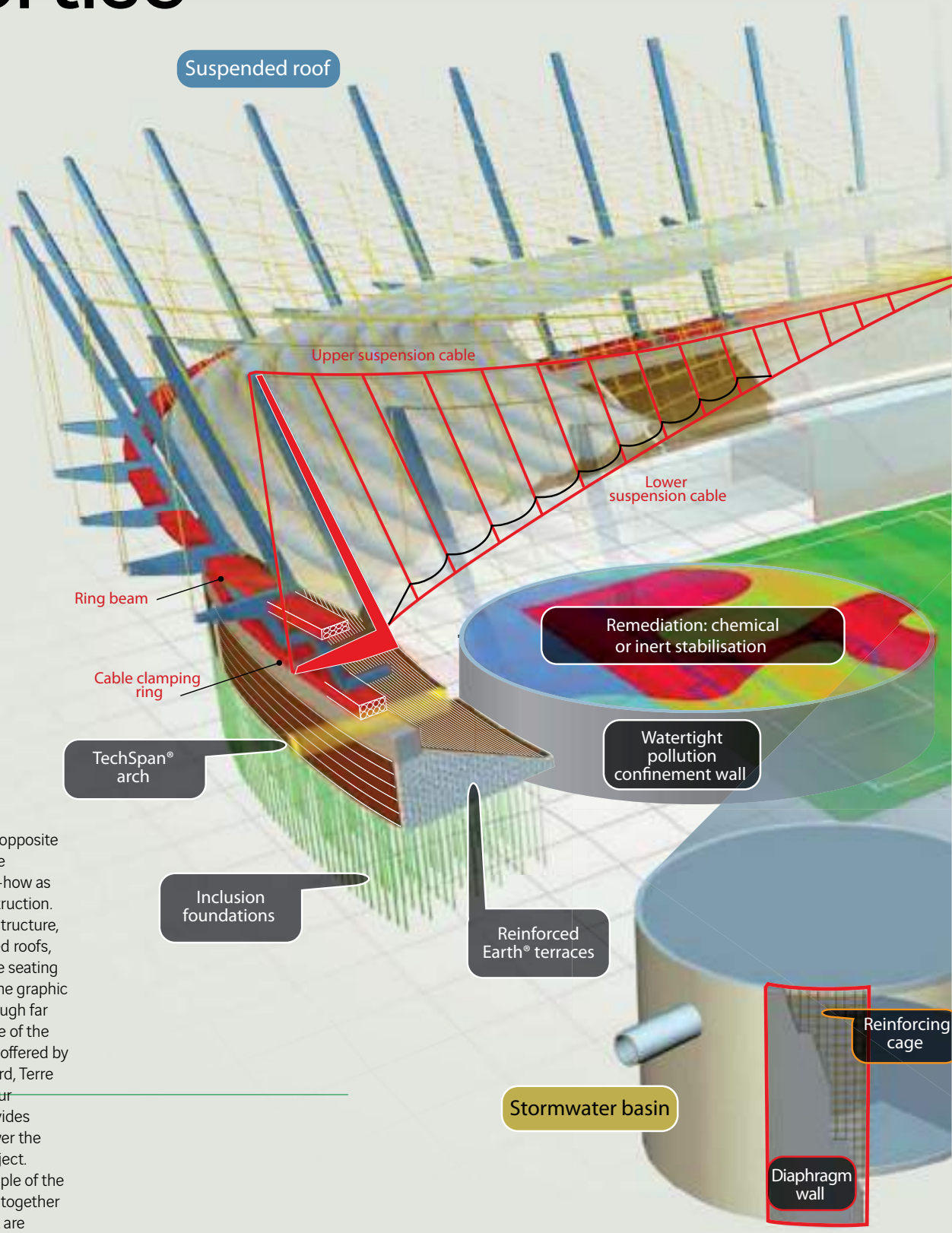
At the beginning of November, after carrying out several tests, USACE decided to extend the grout curtain between the dam and its right abutment. The project was completed before the bad weather set in and has reduced the risk of flooding from 1 in 3 to 1 in 25. This is a much better result than expected and one that earned the Nicholson Construction team the congratulations of Colonel Anthony O. Wright, the Corps' Seattle District commander.

Participants
Client: US Army Corps of Engineers, Seattle District
Contractor: Nicholson Construction

02

03

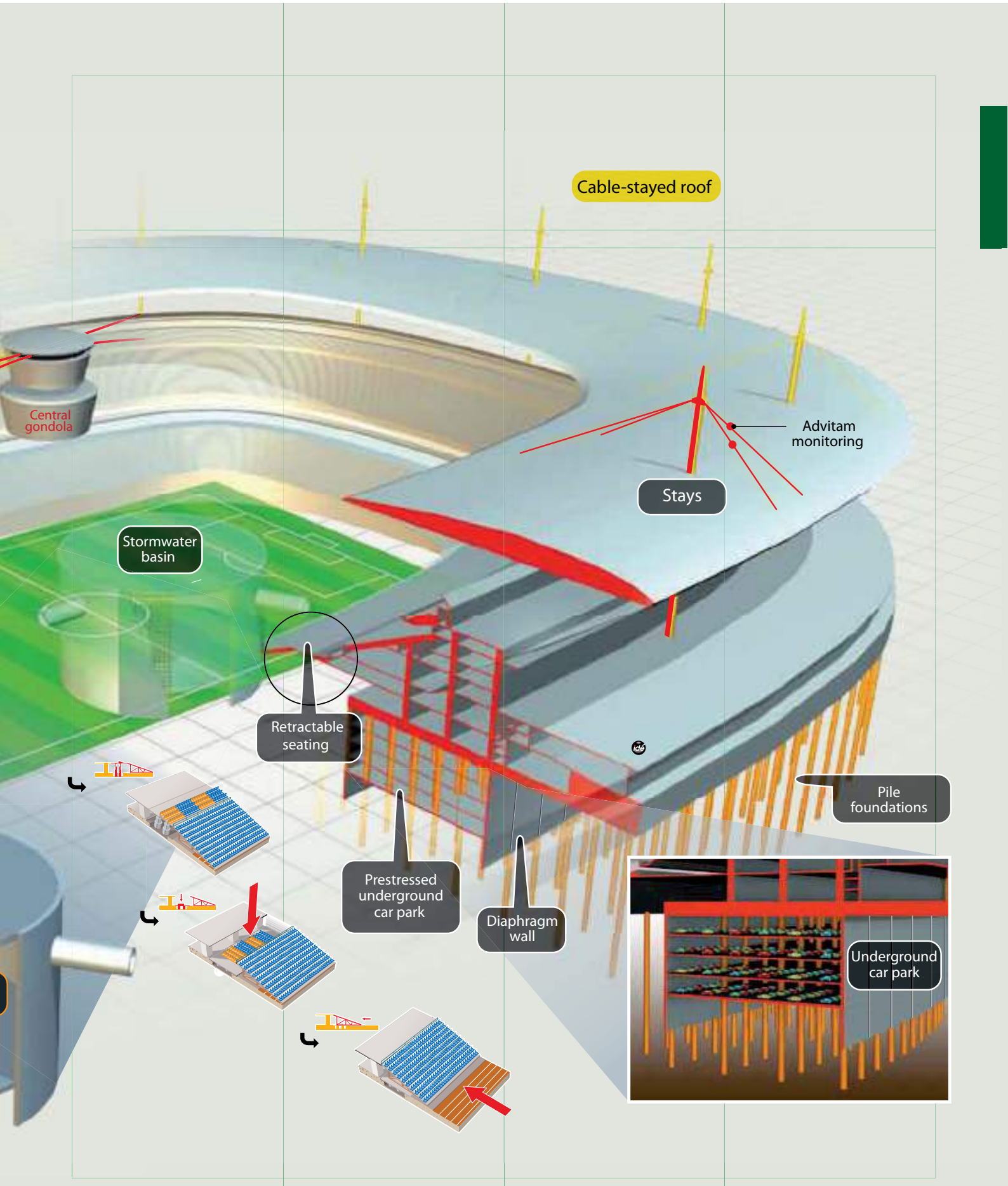
Expertise



01

Know-how
Stadiums

The information graphic opposite highlights the Soletanche Freyssinet group's know-how as applied to stadium construction. From the ground to the structure, foundations to suspended roofs, not forgetting retractable seating and TechSpan® arches, the graphic provides a detailed – though far from exhaustive – picture of the sheer range of expertise offered by Soletanche Bachy, Menard, Terre Armee and Freyssinet. Our combined expertise provides myriad solutions to answer the exact needs of every project. This is an excellent example of the way that we can all work together and of the synergies that are possible *(see Completions on p.36).*


Cable-stayed roof
Central gondola
Advitam monitoring
Stays
Stormwater basin
Retractable seating
Pile foundations
Prestressed underground car park
Diaphragm wall
Underground car park

01

Know-how: stadiums (cont.)
A selection of stadium projects around the world

Ataturk Olympic stadium (Turkey) – 2001 – Freyssinet
Four Freyssinet stays support the roof in the shape of Turkey's national symbol, the crescent.

BC Place stadium, Vancouver (Canada) – 2010/2011 – Freyssinet/Advitam
Renovation of the suspended roof and installation of Advitam's sensors to monitor, among other tasks, real-time load and vibration influencing a structure's stays, ensuring that it stays in good condition.

Stade de France (France) – 1998 – Menard
Site remediation using a variation of the Menard Vacuum atmospheric consolidation process. The system remains in use to this day: accumulated hydrocarbons are regularly pumped out.

Messina (Italy) – 2001 – Terre Armee
Reinforced Earth® diaphragm walls at the Messina stadium, a design whose construction methods and architecture were inspired by the amphitheatres of antiquity.

Stade de France (France) – 1998 – Soletanche Bachy
Diaphragm walls and barrettes for the La Plaine stormwater basin and P2 underground car park beneath the training ground.

Budapest Arena (Hungary) – 2001 – Soletanche Bachy
Use of a hollow stem auger to create 17,000 ml of piles.

02

Equipment
Fraise XS: the Hydrofraise for urban sites

01

02

01 The 20 m kelly guide mast differentiates the new Fraise XS from the conventional Hydrofraise.
02 In another difference compared to its big sister, the Fraise XS makes it possible to create walls of variable thickness, from 500 to 800 mm.

Hydrofraise was a revolutionary drilling machine when it was first developed 30 years ago, as it made it possible to create diaphragm walls in hard ground, and the machinery has undergone continuous improvement ever since. Versions have been released for deep diaphragm cut-off walls for dams (up to 120 m) and for extra thick walls (1.80 m). Conversely, small machines have also been developed for use on sites with space restrictions, especially in terms of free height. "Despite these improvements, there remained opportunities for further progress," says Daniel Perpezat, project leader at Soletanche Bachy's technical department. "An in-house marketing study of operational units in 2008 picked up on some new requirements that were being expressed." Two requirements were cited over and over: a compact machine offering good power and performance so that works could be carried out more rapidly, and a machine capable of going beneath the 630 mm threshold for diaphragm wall thickness. Says Daniel Perpezat: "Where the structure allows, creating a thinner diaphragm wall is a major saving in terms of fill and concrete volumes, and therefore for the amount of energy needed to produce the materials and the plant operation and transport times, all of which are very important factors today in the light of our push for sustainability." These twin key demands became the signature for a new concept, the Fraise XS, a machine that is now operational, having successfully completed its first site intervention. At Soletanche Bachy innovation is encouraged through close cooperation between the technical department and business units (particularly the Paris agency and the EuroFrance plant department). Development in this case concentrated on choosing the best drilling rig to use – one that was compact, powerful and affordable – as well as on designing the tool. The breakthrough came with the availability on the market of the Liebherr LRB 155 rig, whose 450 kW hydraulic power pack was powerful enough to drive the tool without having to fit a dedicated secondary motor. As far as the tool itself was concerned, the project team set out its objectives: the Fraise XS was to be capable of creating diaphragm walls 500 to 800 mm thick, a requirement that led them to design a new pumping system. In place of a cable suspension system, the new tool uses a kelly, a 20 m mast that allows far greater control and verticality for guiding the tool. Daniel Perpezat sums up the project: "Overall, we wanted to create a tool that did fewer things, but did them better, and that would be perfect for use on built-up sites thanks to its compactness, precision and manoeuvrability." In May 2010, while still undergoing commissioning trials, the Fraise XS was used on a test site to create a stormwater basin in very hard limestone in a city centre environment (Auxerre in Burgundy). "As with every operation of this type, we had the Fraise XS and a sludge treatment unit on site," explains Daniel Perpezat. "Having seen how much progress the new tool represented in terms of set-up speed, operational uptime and compactness, we realized we could move on to the second part of our project, which was to develop a more compact sludge treatment plant, designed specifically for use with the Fraise XS."

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01 Smaller improvements were made to the Version 1a grab: self-lubricating ring system in the grab hinge and joints and safe management of the three hydraulic control hoses.
02 The new carrier's power system can directly supply the Menard hydraulic control block.
03 Menard hydraulic control block.
04 In the cab, the operator releases the pounder with the help of a PLC.

03

Process

Mars version 2: improved compaction energy, speed and safety in operations

In 2004, the Al Quo'a worksite in Abu Dhabi, United Arab Emirates, offered Menard an opportunity to put into practice an idea, formulated five years earlier, for upgrading its earliest ground improvement process, dynamic compaction. The technology consists in hammering the ground with a pounder released from great height, thus compacting the ground at depth. Compaction performance is dependent on two factors: the weight of the pounder and the height from which it is dropped. As the Menard Equipment Department explained, "The maximum limits are 35 tonnes and 25 metres respectively, and this was not enough to achieve the performance required at Al Quo'a, so we sought to eliminate all the factors that could slow the descent of the pounder." This led to the idea of a hydraulically controlled grab that could release the pounder into free fall from the highest point and thereby eliminate energy losses due to cable and winch friction. These are substantial due to the block (reducing pulley) installed on the boom to reduce the load on the winch as the pounder is hoisted. Patented in 2004 under the name Mars (Menard Automatic Release System), the system went back to the drawing board in 2009 in the run-up to the A71 motorway project in Leipzig, Germany.

The result was Version 2. Without changing the design, which was fully satisfactory, the Menard Equipment Department adapted the system to a new carrier, the Liebherr HS 895 crane, and worked on the integrated PLC and the reliability of the controls, as requested by operational personnel.

The main change made in the control system relates to the release sequence. The operator retains control at all times, but the pounder cannot be released until the winches have started the descent movement. This avoids the boom recoil that occurred in Version 1 and enhances safety of personnel and equipment.

The use of the Liebherr HS 895 crane is also a major improvement. In contrast to the mechanical cranes ordinarily employed, the Liebherr is equipped with a very powerful (over 900 HP) engine and all its movements are hydraulically controlled. Moreover, the circuit can be slightly modified to enable the available hydraulic energy to directly supply the Menard hydraulic control block, so that no dedicated power pack is needed. Winch power, far superior to that available on other machines, obviates the need for reducing pulleys and spectacularly accelerates pounder hoisting and grab descent, so that operators no longer have to manually control free fall release and grab braking, a tedious operation that always entailed a risk to the equipment. Other smaller improvements were also made: self-lubricating rings on the grab hinge and joints and safe management of the three hydraulic control hoses, on which the Menard Equipment Department continues to work.

04

Product

Mecatiss fire protection mattress: temporary fire protection for curved floors

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03

01 Fire protection on the lower face of the curved floors has to be temporarily removed in order for the seismic protection works to be carried out.
02 - 03 Mecatiss has developed an easy-to-handle system of fire suppression mattresses that are laid on the floors to provide continuity of fire protection during the work.
04 Dismantling the protective anti-fire layer on the lower face.

EDF is carrying out a number of different operations at its nuclear power generation plants as part of its seismic protection programme. Some of the work concerns the ceiling voids in electrical buildings sited next to the reactor enclosures. Known as curved floors, they fulfil a fire protection function. They have to be dismantled before they can be strengthened, but this necessarily involves an interruption to the fire containment mechanisms, which in turn demands that very strict rules are followed and uncompromising safety procedures obeyed. "The compartmentalised fire containment zone can never be left open without temporary fire protection to ensure the safety of equipment and personnel," explains Bernard Marquez, director of Mecatiss (Nuvia). Mecatiss is Nuvia's specialist passive fire protection subsidiary, and has been involved with nuclear reactors in France and other countries since 1980 with its fire protection system (1h30 firewalls for cable runs, MPF.2000 system for curved floors). Mecatiss has designed and developed a temporary fire protection solution to meet the standards required by EDF and national safety bodies.
Bernard Marquez explains that "they are flexible, lightweight mattress-type structures no more than 80 mm thick, meaning that they are easy to handle, and that incorporate a range of chemical components developed by Mecatiss. They are fitted to the upper surface of the floors during the time that interventions are taking place beneath (removal of the existing fire protection system, renovation of the structural metalwork and replacement with a flexible layer of Mecatiss MPF.2000 fire protection) and provide one-and-a-half hours of fire protection."
As with other products Mecatiss has designed for fire protection at nuclear plants, these mattresses were developed to a specification drawn up jointly by EDF and national safety bodies. Having been tested by approved laboratories, these products meet general European standards as well as specific standards required by the nuclear industry.
The fire protection mattresses are installed by Mecatiss, which also conceived and developed them. During the period May 2009 to February 2010, teams from Mecatiss were at work at nuclear reactors in Blayais, Tricastin, Gravelines, Chinon, Dampierre, Saint Laurent des Eaux and Cruas, where they variously deployed then removed the temporary fire protection before refitting the permanent protection, operations that extend on average over a six-month period and that require a team of four.

04

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Process

Transpec® 4: safety at pavement joints

The application of Freyssinet's steel tendons in cable stays and prestressing cables is well known. Less familiar is their use in the Transpec® 4 load transmitter. Freyssinet developed the safety device in response to growing demand from authorities for a way to improve road safety. The problem involved ensuring mechanical continuity of BN4-type safety barriers at pavement expansion joints in an impact. "The pavement joint must move freely to enable the structure to respond to traffic loadings and thermal fluctuations, and this freedom of movement must continue into the guardrails. This means that connecting sleeves cannot be permanently attached to the rails to provide continuity. When there is an accident in the vicinity of the pavement joint, the safety barrier therefore did not have sufficient strength," said Freyssinet product development manager Philippe Salmon, who handled the technical development of the new system. The solution was patterned on the operation of a safety belt: two "blocks" are bolted inside the rails on either side of the pavement joint. They are connected by a prestressing cable with a capacity of 30 tonnes, which is rigidly attached to one of the blocks and flexibly attached to the other. The cable slides freely in normal operation but is blocked under a sudden loading such as vehicle impact.

The system underwent a series of in-house and outside tests *(see opposite)*. The test results were conclusive and prompted authorities in a number of countries, including France, to require the system in both new construction and refurbishment when pavement joints exceed 200 mm in width. The system has already been installed on some 100 structures.

To find out more contact:
Philippe Salmon, Freyssinet (Tel: +33 (0)1 46 01 84 84), Pierre Gruchy, Freyssinet Products Company (Tel: +33 (0)3 85 73 69 00).

02

03

01 In normal operation (top), the tendon slides freely, allowing the rails to move in response to changes in pavement joint clearance. In an impact (bottom), the active block, shown in red, blocks the tendon.

02 - 03 The Transpec® 4 system can be installed on all types of safety barrier provided the free space within the rails is at least 90 x 90 mm.

Proven effectiveness

During testing carried out by Setra at the LIER (Inrets* road equipment laboratory) site in Lyons, two Transpec® 4 devices were installed on the upper rails of a BN4 safety barrier. A 16 t truck struck the barrier at 80 kph at an angle of 20°. The device worked perfectly, with the opening of the rail connecting sleeve remaining negligible.

** Inrets: national transport and transport safety institute*

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02

03

01 Recovering floating hydrocarbons from the bottom of an excavation.
02 Setting up a filter gate.
03 Mavensol mixing machine.

06

Business

Sol Environment: confinement techniques and remediation solutions

Sol Environment, Soletanche Bachy's specialist environmental subsidiary, is celebrating its fifth anniversary this year, after a high profile 2009 when it won the joint FNTP/VINCI Group prize for innovation for the co-development with CSM Bessac of the Proccope* sewer maintenance and cleaning system, as well as signing an effluent treatment deal for a manufacturing site in northern France. The company is headed by Pierre-Yves Klein, who tells us about another type of ground-based know-how, one that's very in keeping with current environmental concerns.

How did the company become interested in environmental activities?
It happened quite naturally; there's not much of a difference between a site environment and the environment in general. It's a field the company first got involved in during the 1980s when we were making watertight diaphragm walls – traditional structures intended to prevent water flooding the foundations on a site – that prevented polluted water from spreading beyond a site, or the construction of preventive barriers around sites where nuclear power stations were being built. Then came other applications, hand in hand with the development of materials able to confine pollutants within the walls (the Ecosol range), filters incorporated into walls (filter gates), formulations capable of rendering hazardous waste inert, and so on; this gradually meant that we expanded the type of work we were tackling, from confinement to remediation.

Were these experimental applications, or was there some type of product line-up?
At the start there wasn't an in-house specialist team, and our offer was left up to the agencies to handle. But it was pretty soon apparent that the customers for applications of this type were not those that Soletanche Bachy dealt with regularly: they were industrial companies or developers looking for all-in-one solutions, and therefore had to be handled a little differently. That's why Sol Environment was set up in mid-2005; its missions were to develop the range of turnkey solutions that this market demands, and to create a viable long-term business. In other words, what we do is bring solutions to our customers, primarily through transferring our expertise in foundations to anything that can be adapted to suit the environmental industry. We therefore work very closely with the technical department for our R&D, and with the EuroFrance region for logistics support for our projects.

What techniques do your all-in-one solutions use?
Lots! The most interesting in recent times has been soil mixing (Mavensol) and boring, a technique that avoids the need to remove and store waste soil; sludge treatment is another that can be turned to environmental applications with a minimum of adaptation. For example, using piling rigs fitted with mixing tools and an æration system we are able to remove certain volatile pollutants (chlorinated solvents) from the ground, or help the natural organic breakdown of hydrocarbons by mixing and aerating them in situ. These are techniques that we've already used on a number of occasions, including at GDF sites (methanol contamination), at Solvay (chlorinated solvents), and on nine contaminated hectares on the eastern side of Renault's Billancourt site. The great advantage is that this can be performed with or without excavating, but always without having to move soil, so the turnaround times and costs are lower. The company's geotechnical expertise and know-how when it comes to working in highly built-up environments or on sites where space is limited are also factors that are directly transferable to environmental applications, helping to make them ever safer.

How would you describe your track record so far?
We've grown strongly over the past five years, although there was a dip in 2009 as a knock-on from the property slump. This hasn't, however, altered our prospects as we operate in an open-ended market where new requirements are a constant feature. One of our strengths is our ability to meet these new demands, even if it involves developing extremely specialised solutions, for example, the industrial sludge treatment developed for zinc manufacturer Nyrstar, at Auby, or sludge resulting from sewer cleaning. These are all developments that are a good fit with our core skills. They provide opportunities for future development.

** See* resonance *No. 1, p.39.*

Principal techniques

- Permeable reactive barrier: fitting ground filters in situ allowing groundwater to be treated as it flows.
- Mavensol: in situ soil remediation using venting and soil mixing.
- Inert stabilisation: rendering pollutants insoluble by mixing them with hydraulic binders.
- Trenchmix: creating vertical soil-cement diaphragm walls up to 10 m in depth.
- ODS: boring to recover floating hydrocarbons from groundwater.
- Injection: in situ ground and groundwater remediation by injecting an active principle via localised boreholes.

01

02

07

Know-how

Foreva®: Freyssinet solutions to control concrete reinforcement corrosion

Contrary to the impression conveyed by its former name of "artificial stone", concrete is not an unchanging material. Moisture, carbonation[1] and chlorination[2] can reduce the protective high pH of new concrete; and water can infiltrate the porous material to great depths, fostering the transformation of reinforcing steel to rust, which swells and ultimately leads to local concrete failure.
"Whatever its origin, corrosion always involves the same processes, driven by the natural tendency of steel to return to its original state as an oxide. In those places where concrete pH is lowest and where the steel comes into contact with moisture, the metal can disaggregate. Stripped from the surface, the atom loses two electrons and becomes an ion. This ionised particle then combines with oxygen in the environment (anode) to form iron oxide. Concomitantly, the two electrons circulating within the steel reinforcement "escape" at the place where the concrete pH is most favourable and create chemical species ($OH\bar{\lambda}$) that locally reinforce pH. This is what "corrosionists" call the formation of a macropile," said Christian Tourneur of the Freyssinet Technical Department. On a millivolt and microampere scale, oxidation operates like a battery, with the oxidised area representing the anode (the positive pole) and the part of the reinforcing steel where the inflow of electrons has a protective effect representing the cathode (the negative pole). This phenomenon underlies the two classes of electronic processes in the Foreva® range of products and services developed by Freyssinet to control corrosion in concrete reinforcing steel *(see box opposite).*
In both processes, anodes are placed near the metal, either at the surface or within the concrete, to artificially force the existing reinforcement to act as a cathode. Hence the generic term "cathodic protection". Two technologies are based on this principle. The first, called "galvanic protection", uses an anode made of a material that corrodes (sacrifices itself) more readily than steel. This technology, an application of the natural electrochemical process called the "galvanic" effect, requires no added current. The second is called "impressed current cathodic protection". Here, the anode is made of a material that is highly resistant to corrosion and electrons are supplied by a direct current source. This technology is designed more particularly for old structures in which the corrosion rate calls for a larger flow of electrons in the cathode. In galvanic protection, an anode made of a metal that oxidises faster than steel (zinc, aluminium, magnesium) is placed near the reinforcing steel where it generates a flow of electrons as it corrodes. These electrons are distributed to the steel via a conducting wire and protect the reinforcement. Two solutions in the Foreva® range are based on the galvanic effect: Foreva® GP Zinc (sprayed surface anode, see following page) and Foreva® GP Guard (internal anode placed in drilled holes, designed especially for use in areas exposed to humidity).
In impressed current cathodic protection, the injected current is supplied by a low-voltage DC generator. In this category, the Foreva® range offers four solutions:
- Foreva® CP Mesh (with anode mesh, for highly chlorinated and carbonated structures);
- Foreva® CP Ribbon (in which the anodes can be placed in the reinforcement cage prior to concreting, for exposed new structures);
- Foreva® CP Coat (electrically conductive anodic coating);
- Foreva® CP Tube (treated titanium internal anodes placed in drilled holes).
These solutions contained in the Freyssinet Foreva® range of products and services have been provided throughout the network

Foreva® range: a comprehensive toolbox to combat corrosion

In addition to the "galvanic" and "cathodic" protection processes, the Foreva® range of solutions for combating corrosion in concrete reinforcing steel includes other processes tailored to the degree of corrosion. At the preventive stage, the protection takes the form of coating, priming, etc. to lengthen the protective effect of the encasement (Foreva® Epx 982, Foreva® Fuge 500, Foreva® Relastic 310). To halt a corrosion process already under way, two methods are offered, depending on the findings: one applies inhibitors to the concrete facing (Foreva® Inhib 400), the other electrochemically decontaminates the encasement (Foreva® PH+, Foreva® Cl-).

01 Buildings along the seafront are exposed to moisture, carbonation and chlorination.
02 In galvanic protection, the sacrificial surface anode (sprayed metal) is connected to the concrete reinforcing steel by a system of stainless steel plates and rods.

for several years and have a substantial track record, including the Noirmoutier bridge piers, the Rance dam structures, port structures in Australia and Hong Kong and, in a more standard application, countless buildings located near the sea.

1. Since concrete is not entirely sealed, atmospheric CO_2 reacts with it to form calcium carbonate, which attacks it, causing a drop in its pH and leading almost inevitably to reinforcing steel corrosion.
2. Attack by sodium chloride (common salt) affects structures exposed to marine climates and those located along roads where de-icing salt is used in winter. Salt penetrates the natural porosity and microcracks in concrete, concentrates moisture and fosters pitting corrosion in steel.

A metal reinforcement protected from marine atmospheres

A Freyssinet operator uses a plasma torch to apply Foreva® GP Zinc galvanic protection to the facade of a building on the seafront. Prior to the metallisation operation, the surface is prepared by sanding and local finishing. To enable the fine zinc layer deposited to act as an anode, electrical connections are installed with the concrete reinforcement using a system of stainless steel plates and rods. A sealer is applied following the Freyssinet treatment; it can be painted over. Foreva® GP Zinc is designed to provide protection for more than 30 years.

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