# Soils&Structures

THE FREYSSINET GROUP MAGAZINE

**REALIZATIONS** PENANG BRIDGE: STAY CABLE REPLACEMENT WITHOUT INTERRUPTING SERVICE

**COMPANY** SPAIN: FIRM FOUNDATIONS FOR OVER 30 YEARS

**HISTORY** TECHSPAN ARCHES

## HANDLING
## A HEAVYWEIGHT SOLUTION FOR LIFTING


N° 224 Second half of 2006

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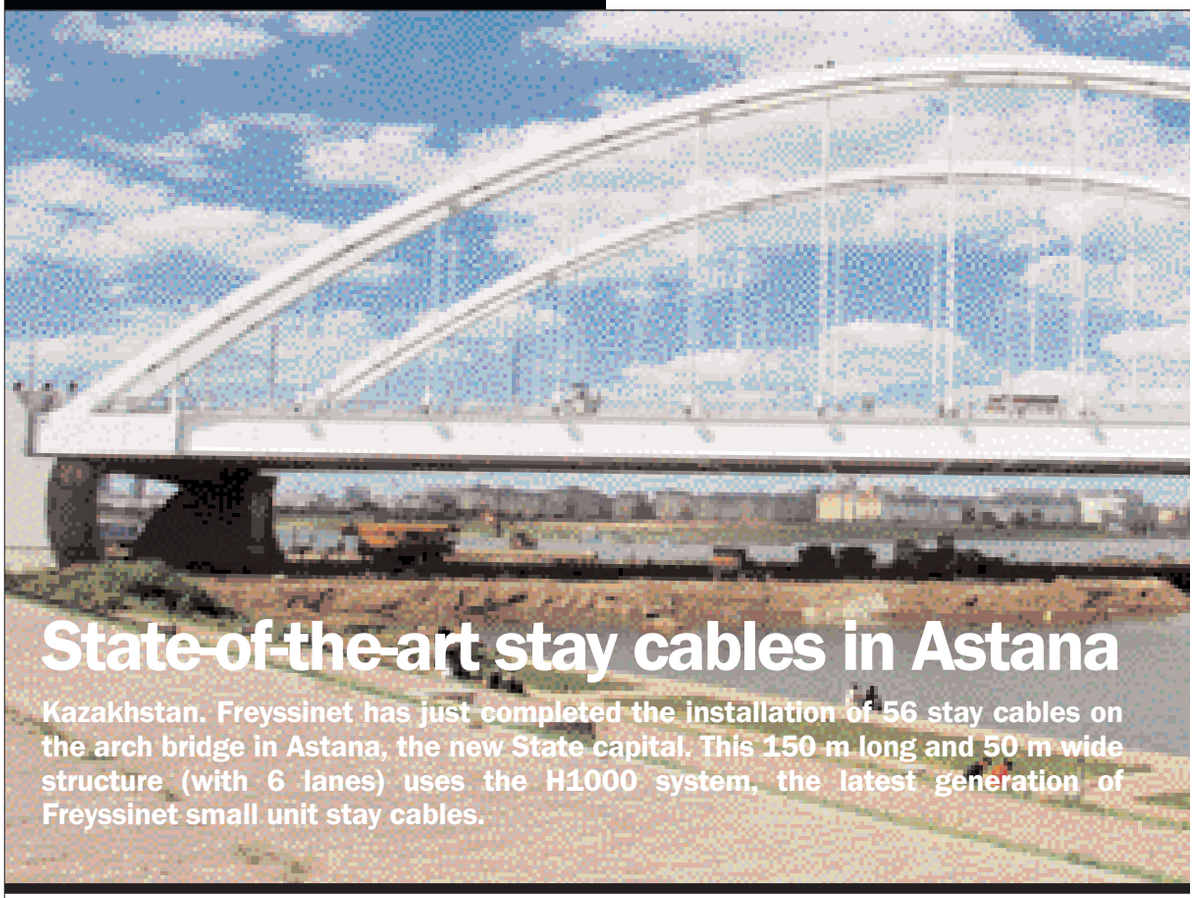
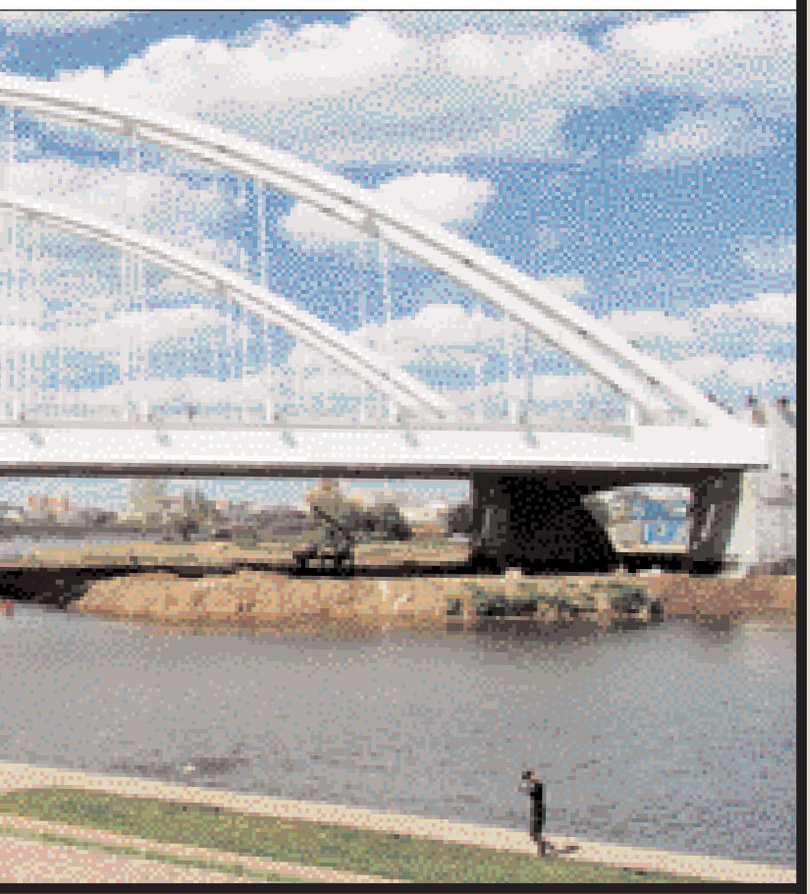


# State-of-the-art stay cables in Astana

**Kazakhstan. Freyssinet has just completed the installation of 56 stay cables on the arch bridge in Astana, the new State capital. This 150 m long and 50 m wide structure (with 6 lanes) uses the H1000 system, the latest generation of Freyssinet small unit stay cables.**

## Completion and start-up

**Morocco.** On the Casablanca-El Jadida motorway, work on the bridge over the Oum er Rebia is coming to an end. Acting as SGTM's sub-contractor for the construction of this 400 m long structure with two separate decks, Freyssinet designed and supplied the mobile rigs and pre-stressing anchors, and supplied and installed the reinforced neoprene bearings (1 x 1 m) and the expansion joints (Cipec WP 400). The company also provided technical support with the prestressing installation.
Further south, between Marrakech and Agadir, the company has also begun the prestressing of three two-deck motorway viaducts. A total of 272 tonnes of prestressing steel will be installed between now and the end of 2007 on the 152 beams that make up these structures.



## Jet-grouting in the city centre

**France.** In the heart of the city of Lyon, Ménard Soltraitement has realized a jet-grouting wall made up of 20 reinforced secant columns 6 to 8 m deep, to enable the construction of an access road to the subway for fire services.

# 53,000 m² of prestressed concrete floors in South-East Asia

**Singapore.**
Between October and December 2006, the singaporian Freyssinet's subsidiary, PSC Freyssinet (S) Pte Ltd, supplied and installed the prestressing (350 tonnes) for the 53,000 m² of concrete floors in the Cendex Centre, a vast service-sector complex comprising 16 floors and 238 offices with car parking facilities under construction along the Lower Delta Road.

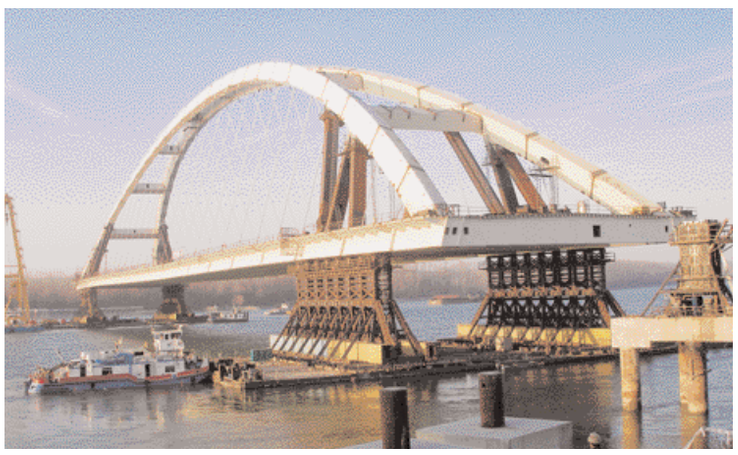
# 6+ PLAN: A NEW DIMENSION

Freyssinet, Reinforced Earth and Ménard are now the three main Group brands under which our teams operate in the business areas of structures and soils.
Overall growth in 2006 was in excess of 20%, buoyed by the favourable climate in our markets.
Our growth was pleasingly even across the two business areas, the three brands and our geographical area, with projects or operations in over 100 countries.
This amazing vitality is above all due to the trust that our clients place in us. We have to be worthy of that trust at all times, bringing care, reliability and excellence in the quality of the service that we provide, in the implementation of our techniques, and in the approachability and organisation of our teams.
That was the thrust of our 4-5-6 plan, which came to an end in 2006. We are now launching the 6+ plan, which takes up where it left off.
We will be continuing with, and further strengthening, our work in research and development, innovation and marketing, and more generally, any activity that contributes to maintaining our clients' trust and breaking into new markets. We will also be adding an additional dimension.
This dimension takes into account all of the parameters of sustainable development, to which the company is committed. We want to lead by example, contributing to sustainability by developing techniques that conserve natural resources and limit $CO^2$ emissions and implementing behaviours and practices that meet these aims.
**"Sustainable Technology"** is our new motto. ■

**Bruno Dupety**
Chairman of Freyssinet

## Arch bridge over the Danube

**Hungary.** As part of a vast Hungarian motorway network development programme, a new bridge is under construction over the Danube at Dunaujvaros, 70 km from Budapest. This 6-lane, 312 m long, 36 m wide structure is situated on the M8 motorway. It is supported by a 48 m high arch, anchored to which are 48 hangers supplied and installed by Pannon Freyssinet, in conjunction with the Freyssinet structures division. The cables are protected by steel HDPE sheathing.



## Six months of consolidation

**France.** Between Lyon and Valence, on the Tricastin uranium enrichment site, soil improvement works on the Georges-Besse II plant were completed by Ménard last August after six months of works. The consolidation of ground below platform, made of clay and silt, required the installation of 30,000 lm of stone columns and 30,000 lm of vibrofloated columns.

## 12,500 m² of Freyssisol walls

**Croatia.** On the Dugopolje-Bisko section of the motorway network that will ultimately link Zagreb, Split and Dubrovnik, Terre Armée has been working as a subcontractor to Viadukt d.d. on the construction of two very high Freyssisol retaining walls. The company designed the walls, assisted with the assembly and supplied the materials and equipment. The structures are situated in Ercegovci and were completed midway through 2006, the first wall (2,500 m²) is 17 m high and the second, under construction in Strikici, is a 10,000 m² stepped wall, 27.50 m high at its highest point.

## 7,240 tonnes of prestressing

**Azerbaijan.** In Baku, Freyssinet's Turkish subsidiary, Freysas, was involved in the construction of a 339 m long structure, for which it supplied and installed the prestressing. Situated at the Ayna-Sultanova crossroads, a total of 7,240 tonnes of prestressing steel has been installed on the bridge.

From right to left: Sean O'Reagain of the European Commission, Ivica Zivanovic, Freyssinet, Michel Vieillefosse, secretary general of Euréka!

## Another grand prize for Cohestrand

**Monaco.** After winning the Grand Prize at the VINCI Innovation Awards in December 2005, Freyssinet's Cohestrand strand has been awarded the Grand Prize at the European Innovation Awards. Created in 1994, the prize aims to promote European industry and applied research and recognises the work of independent researchers, universities and companies in Europe. Developed by Freyssinet's researchers, the Cohestrand strand (which has a lifetime of over 100 years) solves durability problems in main cables of suspended structures.
It was used for the main cables and hangers on the Kanne suspension bridge in Belgium.

## Summer work

**France.** Last July and August saw the continuation of the strengthening and repair work on the arch of the RER line C tunnel between the Gare d'Austerlitz and Quai d'Orsay stations. Carried out by a consortium of companies, including Freyssinet, this work involves the use of two complementary techniques, grouting and shotcrete, implemented in alternate years. Work this year concentrated on the section between the Austerlitz and Invalides stations. Scheduled completion is 2008.

## 95,000 m² of improved soil

**United Arab Emirates.** In October 2006, Ménard Soltraitement began the treatment of a 95,000 m² platform on the side of a lake for the Gulf Hotel project, in the emirate of Abu Dhabi. This will be the site of a future development of man-made hills on which 100 chalets will be built. Two techniques, dynamic compaction and dynamic replacement, are used.

## A new subsidiary in Asia

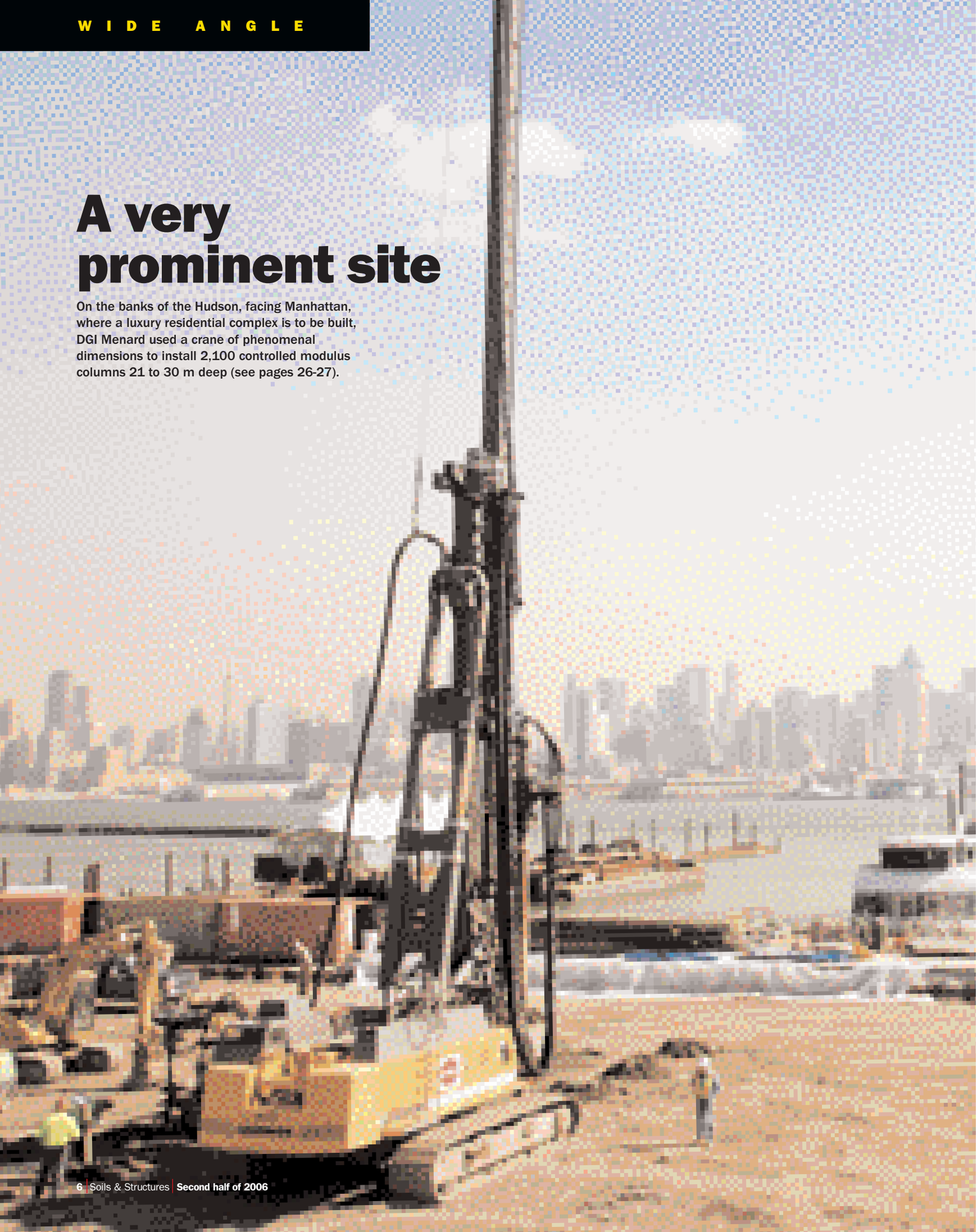
**India.** On Wednesday 22 November 2006, the Group strengthened its Reinforced Earth business in India through external growth. The new subsidiary, called Reinforced Earth India Pvt. Ltd., is managed by Somnath Biswas and has 60 employees spread between its head office in Delhi and three regional offices situated in Bombay (Mumbai), Bangalore and Calcutta (Kolkata). The company provides all the solutions developed by Reinforced Earth in terms of MSE and TechSpan precast arches.
*Contact: www.reinforcedearthindia.com*

## A first in Europe

**Latvia.** In Riga, where the Western Dvina flows into the Baltic, Freyssinet is involved in the construction of a 6-tower cable stayed bridge, the first in Europe to use the deviation saddle/cohesive strand combination (patented by Freyssinet under the name Cohestrand), which was used in Malaysia for the Sungai Muar Bridge (2003). After installing the temporary cables for the launching of the deck, Freyssinet will begin the installation of the permanent stay cables at the beginning of 2007, using 110,000 m of Cohestrand, 48 37HD15 anchors and 2,800 m of orange sheathing.

# A very prominent site

On the banks of the Hudson, facing Manhattan, where a luxury residential complex is to be built, DGI Menard used a crane of phenomenal dimensions to install 2,100 controlled modulus columns 21 to 30 m deep (see pages 26-27).




High-capacity jacks are used in lifting and for any type of sliding or launching operation (sinking in this case), regardless of the structure (overview p. 9).

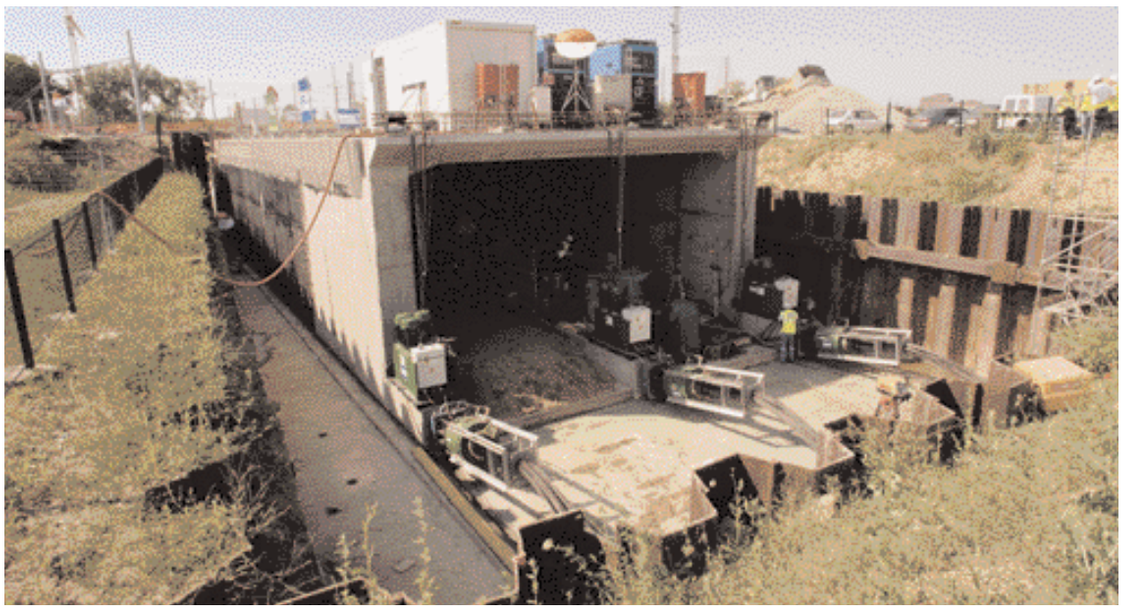
# A HEAVYWEIGHT SOLUTION FOR LIFTING

**Two years after Freyssinet's acquisition of Hebetec, the green jacks of Hindelbank have appeared on many of the Group's sites, confirming its position as one of the leading global players in lifting technologies. The specialty has strengthened its operational capability in installing and handling structures and given rise to new offers.**

A few kilometres east of Berne, Hindelbank, the home of Hebetec, is every inch a large rural village with its chalets and views of meadows where cowbells chime. The imposing gold clock on the village's clock tower may remind us that we're in Switzerland, but it also suggests that despite appearances, time has not stood still here. This is immediately confirmed by our conversation with Hans Hofstetter, managing director of Hebetec, when he sums up the company's business and journey to this point: "Hebetec, a heavy lifting specialist, was formed in 1995 by five people, three of whom (Daniel Schäuble, technical director, Ueli Jakob, director of lifting activities and vice-chairman, and myself) are still with the company. The company now has a workforce of 25, 16 of whom are operators, and sales have increased constantly since its creation by approximately one million Swiss Francs each year. Active in industry and in public works, the company has is represented on all four continents and, since 2000, has been developing two new processes to strengthen and expand its offer: the APS (AirPad-transport-System) and Megasteel systems. "Obviously", continues Hans Hofstetter, "Hebetec did not start from scratch. Lifting is a very high-risk business in which everything rests on expertise and equipment, particularly the jacks, the manufacture and use of which require exceptional technical skills."

### A dual anchoring system

The science of jacks and their associated equipment (anchor blocks, wedges, hydraulic systems) is therefore central to the company's expertise. "Unlike prestressing jacks designed for strand tensioning, lifting jacks must 'swallow' kilometres of cable," explains Daniel Schäuble. "To lift a load over several meters, sometimes even several tens of meters, these tools must have a dual anchoring system, one fixed and attached to the machine frame, the other attached to the piston, each taking up the load as the piston moves." At the heart of the system, the wedges are crucial elements that must alternately, without fail, lock or allow the cables to run free. The manufacturing specifications of ▸▸



**Installation of a railway bridge in Saint-Rémy (Saône-et-Loire) by jack-assisted Autofonçage®.**

"Unlike prestressing jacks, lifting jacks must 'swallow' kilometres of cable."

## Removal of shoring: the science of static lifting

**Less spectacular than lifting, the removal of shoring, like at the end of the first construction phase of the Princesse Letizia conference centre in Oviedo (principality of Asturias) last spring, requires just as much expertise and technical skill. Designed by engineer and architect Santiago Calatrava, this 36,000 m² complex built on the site of a former football ground, which also includes administrative buildings for the regional government, a 144-room hotel and a car park with space for 1,800 cars, is supported by a horizontal U-shaped structure, the three sides of which are made up of six 24 m high metal delta sections, on which the load-bearing slab sits. "When the structure was being built, before the installation of the slab, the overhanging parts were supported by 14 shoring towers 16 to 22 m in height, which had to be removed after the welding work was complete," explains Carlos Perez Rodriguez, Freyssinet methods engineer and works manager. Since the loads taken up by each tower differed, Freyssinet installed 96 hydraulic jacks at the top of the shoring and under the structure, with a unit capacity of between 90 and 250 tonnes. Each tower was equipped with an individual hydraulic circuit so that the operation could be adapted to the deformations of the structure.**

**Thanks to an 18-channel LAO (computer aided lifting) system with centralized control, the shoring system could be removed gradually, with real-time control of the loads on the jacks and the deformations of the structure. The operation consisted firstly of loading the jacks and then of lowering them to free the shoring, thus enabling the principal structure to take its own weight again. "To the great satisfaction of the architect and the client," says Carlos Perez Rodriquez, "this system, in collaboration with Freyssinet France, enabled us to unload the jacks and remove all the towers in just one day, 15 March 2006."**

PARTICIPANTS • **Owner:** municipality of Oviedo • **Project manager:** Fiaga SA • **Architect:** Santiago Calatrava SA • **Specialist contractors:** Freyssinet SA and Freyssinet France.

►►these components are therefore extremely stringent, both in terms of the dimensional tolerances and the material composition, which are kept secret. "The patented Hebetec wedge has been tested by the Swiss inspection agency TÜV and each batch is delivered by the manufacturer with certificates of conformity (materials, inspections, etc.)," emphasises Daniel Schäuble.

### Design, maintenance, and on-site work

The quality requirements in terms of equipment extend directly to human skills: in 1995, the operators were none other than the founders, who worked in the office to cover sales duties and produce designs for projects, in the workshop to prepare and service the equipment, and on site. Eleven years later, people remain at the forefront of Hebetec, which prides itself on their professionalism borne of skill and care. With no specific training and very varied careers - some have come from earthworking activities, others from automotive mechanics, etc. - what they all have in common is their knowledge and passion for machines and their flexibility, as lifting is an industry that involves a lot of travel. "One operator was in South Korea for a site installation, and recently went to supervise another installation in Spain before returning to Korea for the operational phase," recounts Beat Joss, project manager at Hebetec. This particularity, along with the nature of the work, which almost always involves spectacular projects, is an attractive feature of the business and an important motivating factor for the guys. "We place more trust in the men than the machines," continues Beat Joss, "because the essential part of lifting is to keep control under all circumstances." Regardless of the number of jacks used and the size of the structure to be lifted, the operators' primary control tools are still the hydraulic system pressure gauges, the laser systems used to monitor the operation and... vigilance at all times.

### Standard stroke and full reconditioning

This approach, which inextricably links knowledge of the tools and a clear understanding by the operators of their responsibilities, is taken a long way at Hebetec. The number of units used is intentionally limited so that everyone knows them inside out, and they all comply with identical standards. With a capacity of 10, 40, 70, 140, 200, 400 or 600 tonnes, all of the Hebetec jacks are the same height and have the same stroke, so that they can be used in series and controlled by the same control station.

As a logical consequence of man working so closely with machine, the greatest care and attention is always given to Hebetec tools. On their return to the workshop, all of the machines are completely dismantled, cleaned, possibly repaired, tested and repainted if necessary, "so that they function impeccably on the next site and out of respect for the customer's trust in us," says Beat Joss, "because heavy lifting is never a run-of-the-mill operation."

Initially working in Europe, mainly Germany, on power station construction sites where 4,600 ►►

"The spectacular nature of the work is an attractive feature of the business and a motivating factor for young people."

1 2

**1.** With its APS (Air Pad-transport-System), Hebetec moves ships weighing over 20,000 tonnes on the shipyards of South Korea. Built on dry land, the ships are moved over several tens of meters to the launch barge.

**2.** Using 140 units, each with a unit capacity of 250 tonnes, the APS system used on shipyards uses the air cushion principle.

**3.** At Brisbane airport at the end of 2004, Australian subsidiary Austress Freyssinet, in collaboration with Hebetec, lifted a 3,000 tonne roof for the largest airport hanger in Australia.

**4.** On the Centennial Bridge that joins the two banks of the Panama Canal, Freyssinet lifted the mobile rigs (390 tonnes) to a height of 70 m using 180-tonne capacity strand jacks.

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## 1,300 tonnes of concrete on an air cushion

On 19 and 20 August 2006, Forges-les-Eaux, a small commune in Seine-Maritime (France), struck level crossing 24 on the Saint-Roch – Darnétal line from its map and constructed an underpass on the RD195. This sliding operation was a first. The APS air cushion method developed by Hebetec for shipyards was used for the first time on a public works project. Unlike the structures normally installed by Autoripage®, this project involved a 1,300 tonne π-shaped bridge (without raft). The structure first of all had to be shored using approximately 70 tonnes of Megasteel elements so that the entire load, and particularly that of the abutments, was taken up by the APS units. The eight units, with a unit capacity of 380 tonnes, were arranged in two lines on two accurately positioned 45 m stringers serving as guide rails. Thus prepared, the structure was installed by a 3-person team at a speed of 20 m/hr and with a friction coefficient of less than 1%. "As an addition to sliding on bentonite," says Jean-Luc Bringer, "this method means that Freyssinet now has a broader range of resources for numerous structures with all kinds of configuration."

PARTICIPANTS • **Owner:** RFF • **Project manager:** SNCF. **Contractor:** DG Construction • **Slide rails and air pad sliding:** Freyssinet/Hebetec (design, methods and execution).

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**1.** In 2005, Freyssinet lifted the three back spans (2,000 tonnes) of the Shenzhen Western Corridor, a 3.8 km viaduct linking Hong Kong and China, as well as the segments of the main span (250 tonnes). Each operation took eight state-of-the-art automatic strand jacks with a unit capacity of 300 tonnes.

**2.** To lift the roof of the Swiss Campione casino (1,100 tonnes) to a height of 30 m, Freyssinet developed a linear winch system with cables controlled by a monitoring system allowing for automatic lifting. Movements were controlled by laser sensors.

**3.** Begun in 2003, the Plock bridge is the largest cable-stayed structure in Poland. In addition to installing the stay cables, Freyssinet's Polish subsidiary also lifted the approach spans (600 tonnes) using a lifting frame and hydraulic jacks, and lifted the segments for the central span. The segments were brought by river and hoisted into position using a system of cables and hydraulic jacks with a total capacity of 4,710 kN.

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▶▶tonne structures had to be lifted, the men from Hebetec and their green jacks have diversified their activities and extended their geographical remit by working on off-shore and public works projects (nuclear power stations, tunnel caissons, civil engineering structures, etc.) in Asia and then in Australia from 1999, on projects involving handling and sliding, calling for the adaptation of methods.

At the same time, the company was faced with new requirements, particularly for structures. As a natural addition to lifting tools, Hebetec needed to be able to offer clients turnkey solutions that did not mean that they had to manage several different suppliers. Thus, 2000 saw the emergence of the Megasteel profiles, a "lego system" based on the use of four profile types with a capacity of 150 to 2,000 kN and rigorously standardized dimensions, for all types of shoring or lifting towers. In 2006, a shoring system of this kind, consisting of 200 tonnes of profiles carried by 40 trucks to Austria, was used to install 80 jacks and

lift the roof of Salzburg football stadium, a 140 x 180 m structure weighing 2,100 tonnes, 11 m.

### 22,000 tonnes of steel and concrete on an air cushion

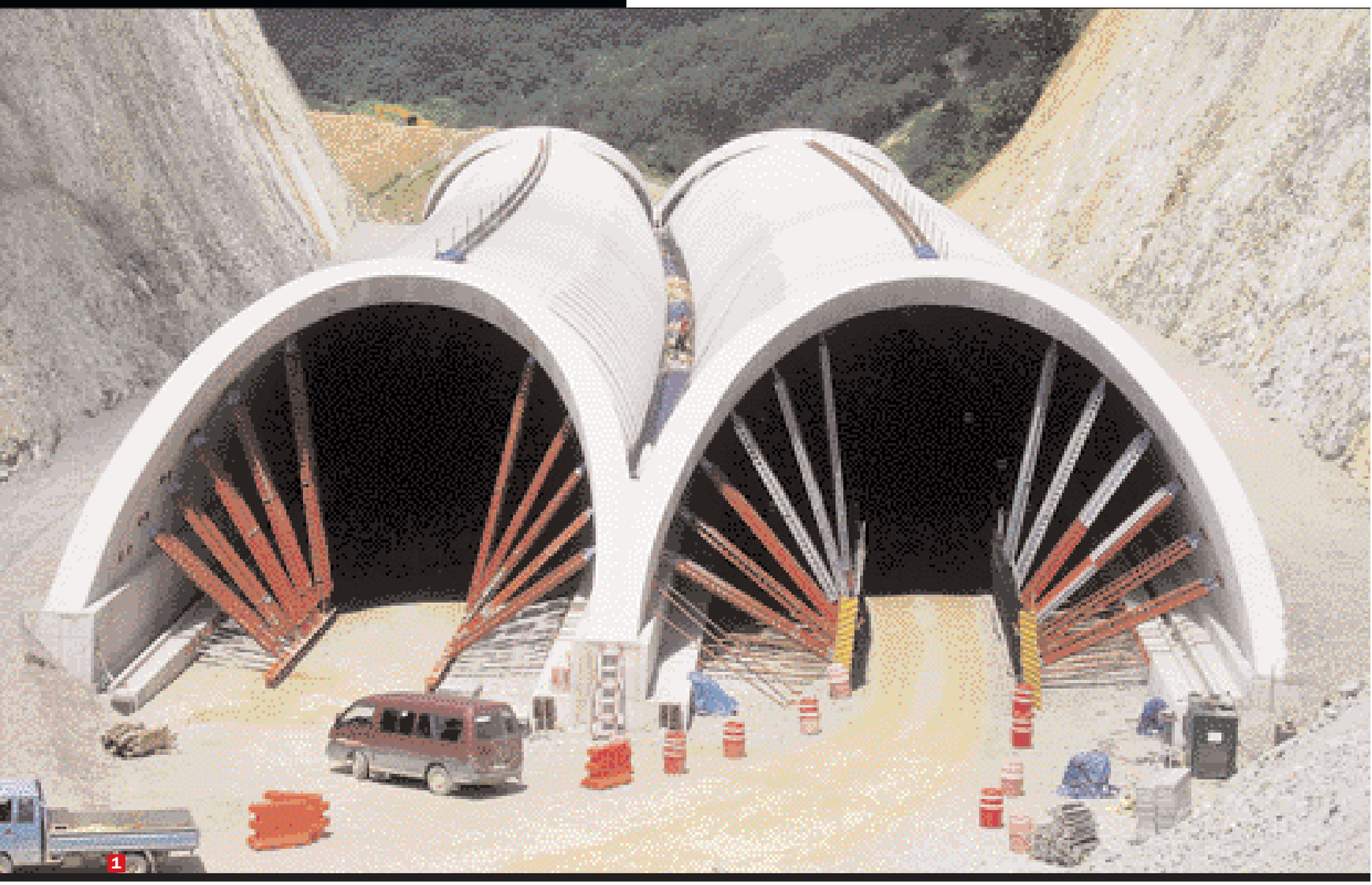
Developed more recently for sliding operations, the patented APS (Air Pad-transport-System) method was used to spectacular effect in the Far Eastern shipbuilding industry, before being successfully adapted, on Freyssinet's initiative, for the installation by sliding of a civil engineering structure at Forges-les-Eaux, in Seine-Maritime (see box p. 12).
Two units with a capacity of 250 and 380 tonnes are used in this application, which requires no anchor blocks, wedges or cables. The objective is to raise rather than lift a load to move it transversally using an air cushion to bring the friction coefficient down to a very low value (0.5%). Each APS unit lies on a sort of air pad. A dual hydraulic and pneumatic system ensures the operation of the system, the first deploying the jack arms so that supporting structure (the blocks) takes up the load, while the second generates an air cushion by injecting nitrogen into the jack ring at 35 bars. In 2004 at a shipyard in South Korea, a 22,000 tonne tanker was moved over 91 m from the construction site on dry land to the launch barge, by installing 140 250-tonne units set out in four lines (push and pull units). This solution is doubly economical, as it frees shipbuilders from the constraint of having dry docks, rendering their costly construction unnecessary; it has since been used for some twenty ships built by Hyundai and is now being used in China.
In the workshop leading adjacent to the offices, where the smell of hot oil fills the air, the visit ends with a quick inventory of the tools, some of which, currently gleaming, have returned from French sites. The use of the Swiss equipment, hired by Freyssinet to expand its lifting and handling business, is one of the results of the merger that took place two years ago. "It doesn't stop there," continues Beat Joss, "since new contacts are entered into every two to three weeks with entities of the Group, and are behind operations in Thailand, Turkey (with Freyssinet International) and Australia and numerous new design projects." ■

# An extension to the prestressing business to maintain, consolidate and internationalize

Commenting on the merger between Freyssinet and Hebetec in October 2004, Jean-Luc Bringer, director of the Freyssinet SCCM (Centralised Cables and Handling Department) believes that "for Freyssinet, the incorporation of Hebetec provides access to a great deal of equipment and fantastic expertise. Reciprocally, new markets are opening up for Hebetec thanks to the Group's network."
Beyond these mutual opportunities, the merger has in particular enabled Freyssinet, with resources equal to requirements (and its ambitions), to develop a specialty inextricably linked to its activities, whether this be methods for installing new structures (launching, pushing, etc.) or handling methods for repair purposes. "As with prestressing, heavy lifting uses high-capacity jacks and cables. It constitutes a significant part of our traditional business, and a skill that we must maintain, consolidate and internationalize."
Hebetec thus completes the teams and equipment of Freyssinet, which, having been at the very beginnings of cable-based lifting at the end of the 1970s, has completed brilliant projects such as lifting the roof of the Campione casino (1,100 tonnes) in Switzerland in 2004 and the three spans (2,000 tonnes) of the Shenzhen Western Corridor between China and Hong Kong in 2005.

### A method with a bright future

The objective for Freyssinet is to create the best offerings by playing on the synergies between the different components. This is notably the case for sliding civil engineering structures, a technique combining the skills of Hebetec for the equipment and even Advitam (a VINCI subsidiary) for the positioning of control instruments. In 2006, some fifteen operations of this type took place, the pilot being the Forges-les Eaux project, in which the Hebetec Megasteel and APS systems were used. "This method, which enabled us to install, in only a few hours, a precast railway structure in immediate proximity to the structure to be replaced, thereby keeping traffic disruption to a minimum, has a bright future," believes Jean-Luc Bringer. "Seven or eight new operations have already been planned for 2007. With Hebetec's contribution, we will be able to extend our solutions to new clients and work towards making them internationally available via our network of subsidiaries." ■



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SOILS/**MOTORWAY TUNNELS AND HYDRAULIC STRUCTURES**

# TechSpan arches enter South Korea in force

**To meet the challenges of its first TechSpan arch projects (three ambitious orders constituting a total length of more than 2,000 m), Freyssinet Korea (South Korea) found support in the expertise of its Australian sister company Reinforced Earth.**

THE CROSSING A MOUNTAINOUS REGION in the centre of the country and the environmental integration of the future structure led the owner of the new Cheongwon-Sangju motorway to opt for cut-and-cover tunnels. The design and construction of two double tunnels, called Naeseo 1 and Whaseo 2 after two nearby towns, has been entrusted to Freyssinet Korea, in its first contract for TechSpan arches. Before work started, and to ensure its best chance of success in this first contract, the company sent two of its engineers to perfect their knowledge of this technology at Reinforced Earth, the Group's Australian subsidiary. After validating the designs, Reinforced Earth confirmed its support to its Korean counterpart by sending specialist Dennis Bernecker to the site for the works phase.

### Four half-arches every four hours

Work began first on Naeseo 1, with the installation in September 2005 of a prefabrication plant on a site adjoining the work area. "Until December 2005, our 11-person team completed an average of four reinforcement cages per day, enabling us to achieve a production rate of four TechSpan half-arches every four hours," says Steve Park,


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**1. The Naeseo 1 double tunnel consists of 256 TechSpan half-sections and is 135 m long. All that remains is to install 15 m of backfill.**
**2 and 3. Preparation of the reinforcement cages for the TechSpan units .**
**4. Arch element storage area.**

head of Reinforced Earth business at Freyssinet Korea. The work continued from October 2005 to March 2006 to lay the foundation footings and then assemble the arches themselves. "The parallel tunnels are 135 m in length and required the installation of 256 half-sections. Neither the widths nor heights of the structures were identical, varying, respectively, from 12 to 14.60 m and from 6.60 to 7.20 m," explains Hee Chan Jeong, the Freyssinet Korea site manager. In mid-September 2006, the work on the first structure was completed with the laying of 15 m of backfill over the tunnels, signalling the start of work on Whaseo 2, situated just 5 km away.

Meanwhile, the Freyssinet Korea teams had begun another TechSpan arch project, this time for a hydraulic application in the south-east of the country, near Taebak. This longer structure (790 m), also consists of two tunnels, but with an opening of 6 m and a height of 4.50 m. "We produced 623 TechSpan half-sections to construct this drainage structure between September 2005 and July 2006," says Seug Mun Lee, the Freyssinet Korea site manager. "The elements were then assembled in just two months, between June and August, using a 130 tonne-capacity crane, after the footings were laid. The structure was then covered with 22 m of backfill." ■

## PARTICIPANTS

MOTORWAY TUNNELS
- **Owner:** Korea Highway Co.
- **Project Manager:** Dongil Engineering Co.
- **Main Contractor:** Korea Development Co., Ltd.
- **Specialist Contractor:** Freyssinet Korea.

TAEBAK HYDRAULIC STRUCTURE
- **Owner:** town of Taebak.
- **Project Manager:** Woodae Engineering Co.
- **Main Contractor:** Kolon Construction Co., Ltd.
- **Specialist Contractor:** Freyssinet Korea.

SOILS/**RUGELEY FLOOD RELIEF ARCHES**

# Precast arches and Reinforced Earth with welded mesh facings

**Behind its brick cladding, the new three-arch Rugeley flood relief structure (United Kingdom) is made up of TechSpan arches and TerraTrel welded mesh.**

AFTER the industrial decline of the 1990s, Mid-Staffordshire, to the north of Birmingham, and in particular the town of Rugeley, has launched a vast regeneration programme of its local infrastructure, an essential precursor to the region's economic recovery. Among other projects, the Rugeley Eastern Bypass, aiming to divert the huge flow of traffic using the A51 away from the town centre, involved replacing an old brick arch bridge with a similar structure. "In architectural terms, this new structure had to be in harmony with the adjacent Grade II listed bridge over the River Trent," explains David Halifax, Project Engineer at Reinforced Earth Company. The second significant constraint was the client's requirement to keep traffic flowing for the duration of the works.

### Two-pinned instead of three-pinned arches

"Although the initial plan was for an arch with reinforced concrete retaining walls, we were able to offer an alternative using Reinforced Earth, giving substantial savings," explains David Halifax. The use of a 4 m high temporary TerraTrel retaining structure along the centreline of the new bridge proved to be perfect for constructing the structure in two phases. Half of the bridge could therefore be built without disrupting traffic using the old structure. With this first phase completed, the traffic could be diverted to the new structure and the demolition of the old bridge could begin.

To simplify and accelerate construction, the TechSpan arches were designed in the form of a two-pinned arch instead of the three-pinned arches used normally. Just two days were needed to install all 27 arch units. The 23 tonne TechSpan arch units with a span of 12 m and an overall length of 18 m were installed on cast in-situ reinforced concrete footings. Construction of the spandrel and wing walls benefited from the choice of TerraTrel welded mesh facings (740 $m^2$), since the elements could be cut to the exact profile of the arches before their brick cladding was applied. Higher up, the precast concrete vehicle parapet was also brick-clad. ■

**PARTICIPANTS**

- **Owner:** Staffordshire County Council.
- **Main Contractor:** Wrekin Construction.
- **Sub-contractor for the arch erection:** Reinforced Earth Company
- **Project Designer:** Staffordshire County Council Highways Department.
- **Specialist Designer:** Reinforced Earth Company

STRUCTURES/**FORT LAUDERDALE VIADUCT**

# Post-Tensioning inspection and repair

**The Freyssinet teams inspected 10,000 m of internal bonded PT cables and 628 anchor heads.**

AT THE CROSSROADS OF THE I75 AND I585 HIGHWAYS IN FLORIDA, Freyssinet LLC was involved in a pilot inspection and rehabilitation operation on the longer of the Fort Lauderdale interchange viaducts. To identify any missing grout on the internal prestressing sheaths, and without accurate plans, MJ Construction called on the expertise of Freyssinet LLC. The operation began, using a georadar (GPR), with the detection of the multi-strand cables inside the concrete.

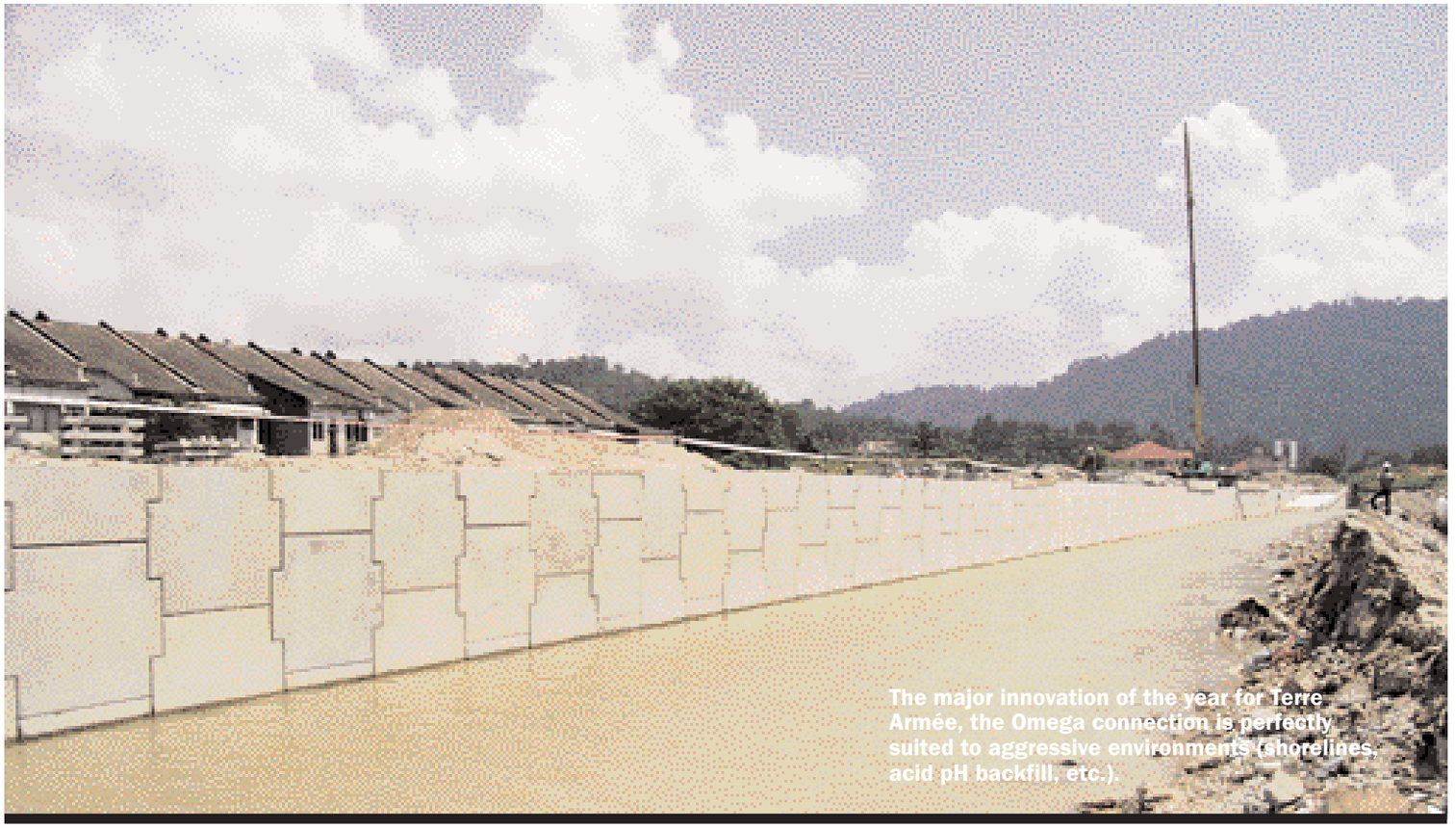
### Analysis and photographs of the strands in the concrete

The team then carried out cable-by-cable inspection surveys with a drilling equipment fitted with an automated stop function on contact with the strand to check the grout presence and quality. It then took volumetric measurements of the voids and analysed and photographed the strand condition using a 4 m long 7 mm diameter endoscope. A major innovation in this project was the development of a new pressure and leak compensated "volumeter" with a digital read-out, affording a precise measurement of the cavity volumes. With this data, the measurement of the grout volumes enabled the quality control of the repair work to be assessed.

"We inspected 10,000 m of cables and 628 anchor heads and were able to submit an accurate report to the FDOT (Florida Department of Transportation) and carry out grouting work where necessary," explains Felix Torres, the Freyssinet LLC site manager. 6,400 l of cement grout were used. Additionally, after inspecting the viaduct's 628 anchors, Freyssinet installed permanent plastic caps before re-grouting the anchors. ■

**PARTICIPANTS**

- **Owner:** FDOT.
- **Main Contractor:** MJ Construction.
- **Specialist Contractor:** Freyssinet LLC



The major innovation of the year for Terre Armée, the Omega connection is perfectly suited to aggressive environments (shorelines, acid pH backfill, etc.).

SOILS/**RETAINING WALLS FOR THE BANKS OF AMPANG RIVER, KUALA LUMPUR, MALAYSIA**

# The Omega connection is exported

**In Malaysia, in the capital city of Kuala Lumpur, two river bank retaining walls are being constructed using the Omega synthetic connection system recently developed by Reinforced Earth.**

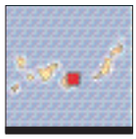
Near Taman Kosas, east of Kuala Lumpur (Malaysia), a prominent development project aims to breathe new life into an area in the suburbs. Shop lots, restaurants and retail spaces will be built along a one mile stretch of the Ampang River where wooden stalls and makeshift buildings were crammed together in former times. Prior to this there was a requirement to stabilise the banks of the river. Reinforced Earth Management Services S/B, the Malaysian subsidiary of the Group, was given the task by the developer GMH Properties Sdn Bhd to design and supply the elements needed to build the river bank walls. "The two structures face each other and measure 800 m and 868 m over a mean height of 3.70 m, with a total surface area of 6,219 m$^2$. Construction of the walls was made possible by diverting the course of the river, explains Tan Gee Hoi, Managing Director of Reinforced Earth Management Services. In view of their particular environment – the water level in the river is designed up to 600 mm from the top of the structures during high-water periods – these 14 cm thick smooth cruciform panels are an implementation of the Omega connection system by Terre Armée."

The product of a programme conducted by SoilTech, the R&D division of Terre Armée, this system eliminates the use of metal structural components at the connection between the panel and the synthetic reinforcement, thus enables the retaining structures to be located in corrosive environments (marine environments, acid pH backfills, pollution risks, etc.) that generally impose severe constraints on implementation. "The concrete panel, its synthetic reinforcement and the connection will now constitute a system which is totally unaffected by corrosion. This retaining wall system is therefore free from such environmental constraints", stresses Nicolas Freitag, who is in charge of SoilTech. Besides being unaffected by corrosion, the Omega connection offers other benefits which include simplified assembly process as it is incorporated in the panel at the prefabrication stage; reduction in the number of elements delivered to site; optimum pull-out strength of the anchor; and adaptability to all types of cladding panels.

Implemented for the first time in June 2005 on an road junction at Morzine (Haute-Savoie, France), this system has just been awarded the Ivor label (Innovations proven on reference structures), the aim of which is to promote development and dissemination of technical innovations in civil engineering in France and internationally. ■

SOILS AND STRUCTURES/**ESCALERITAS BRIDGE**

# 80 tonnes of stay cables and 1,736 m² of retaining walls



## In Las Palmas (Canary Islands), Freyssinet SA and Tierra Armada were simultaneously involved in the construction of a new civil engineering structure.

VISIBLE FROM A DISTANCE WITH ITS SINGLE METAL TOWER overlooking the Ballena valley from a height of 35 m, the new bridge linking avenida de Escaleritas to the district of La Feria in Las Palmas (Gran Canaria), consists of a 100 m cable-stayed span and three secondary spans of 42, 42 and 36 m. With a width of 21.50 m, the mixed deck holds two lanes of traffic and a 3 m walkway on each side of the 2.50 m central reservation.

"The arrangement of the stay cables is where the originality of the structure lies," points out Oscar Ramón Ramos Gutiérrez, chief project engineer for Apia XXI, "because the central reservation receives the anchors of the 10 front stay cables in a single plane, while the 20 back stay cables fan out into two groups anchored in two concrete walls."

### 30 stay cables in four weeks

With a length of between 24 and 100 m, the stay cables are fixed on 12HD15 to 75HD15 type anchors, adjustable at the mast but fixed to the deck. "In accordance with the client's schedule," explains Carlos Pérez Rodriguez, works manager for Freyssinet SA, "we supplied and installed the 30 stay cables in four weeks, with 80 tonnes of Freyssinet Monostrand strands, galvanized, wax-protected and inserted into double-fillet white high-density polyethylene (HDPE) sheathing, the lower part of which is protected by stainless steel vandal-proof tubes. All of the tube-guides were designed to account for the possible installation of dampers on the longest stay cables."

At the foot of the structure, Spanish subsidiary Tierra Armada was not sitting back. Together with the design firm, it designed and carried out the calculations for the bridge abutment walls. For better visual integration with the future sporting area being developed in the Ballena valley, the panels, cast in the Tierra Armada workshops in Las Palmas, are decorated with architectural motifs. The first abutment, on the La Feria side, which is terraced over five levels (1,170 m²) and reaches a maximum height of 7.50 m, ensures continuity with the adjacent embankment. Opposite it, the second abutment, situated on a steeper bank, is shorter (566 m²) but reaches a height of 15 m. ■

### PARTICIPANTS

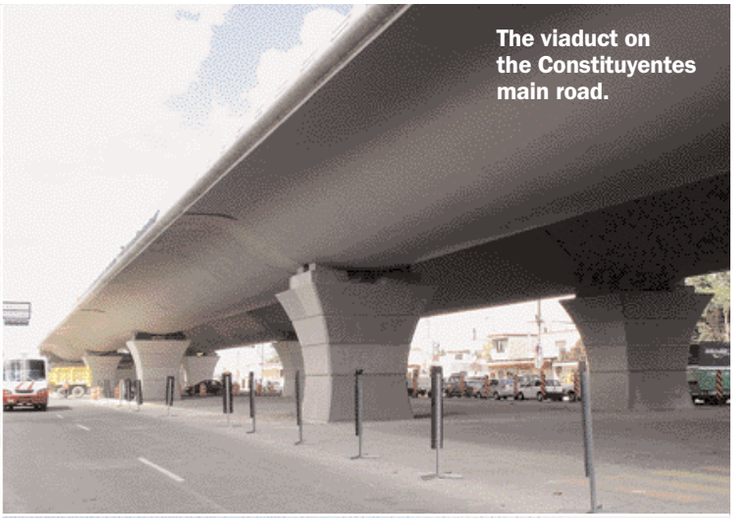
- **Owner:** Municipality of Las Palmas and regional government of Gran Canaria.
- **Design:** Apia XXI.
- **Project Manager:** Dragados.
- **Specialist Contractors:** Freyssinet SA and Tierra Armada.


**AN ILLUSTRATION OF TWO AREAS OF EXPERTISE of the Freyssinet group, the Escaleritas bridge combines stay cables and retaining walls.**

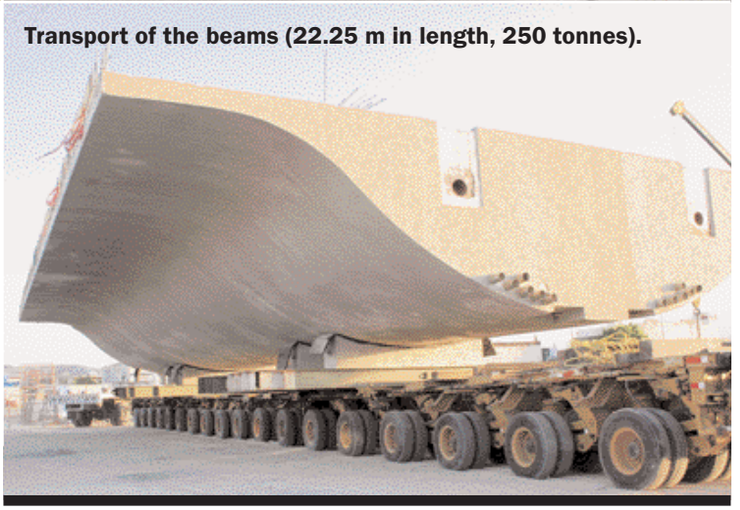
STRUCTURES/**QUERÉTARO BRIDGES**

# Three structures and a great deal of expertise

The prefabrication plant.



The viaduct on the Constituyentes main road.



Transport of the beams (22.25 m in length, 250 tonnes).

## 200 km north of Mexico City (Mexico), in August 2006 Freyssinet de México completed the construction of three road bridges as general contractor in the town of Querétaro.

IN 2005, THE DESIRE TO IMPROVE THE ROAD NETWORK OF THE TOWN of Querétaro led the government of the state of the same name to schedule a vast development project over two years, the key part being the modernization of the Constituyentes main road. The project involved the construction of several civil engineering structures, roads and junctions. Subsidiary Freyssinet de Mexico assisted by constructing the three bridges – Hacienda Grande, El Pocito and Tejeda. With identical widths of 24 m, but, respectively, 135 m (three spans) and 180 m (four spans) long, the first two structures each accommodate six lanes of traffic. The shorter third structure (45 m) has only one span and a width of 27 m.

The three bridges consist of 45 m long precast beams, which themselves consist of two 22.25 m beams joined by a 50 cm connection. Transversally, each structure consists of two 12 m caisson sections with a curved intrados. On each side, access to the lanes is by Reinforced Earth slip roads with a total area of 9,900 m2, for which Freyssinet produced special 3 x 1.5 m moulds. As main contractor and assisted by the Group's Spanish subsidiary, Freyssinet de México was involved in the project at a very early stage, taking part in the land surveys and geotechnical studies and the coating and soil mechanics studies, the geometric and structural adaptation of the bridges and the installation of all of the site safety signage. The company was also in charge of installing a prefabrication plant on the Mexico City-Querétaro motorway, approximately 8 km from the furthest bridge, for the production of the facing panels for the Reinforced Earth structures and the prestressed beams. The company carried out the excavation work for the bridge foundations, the footings, the reinforcements, the formwork and the casting of the piles and service towers. Finally, it supplied and installed the neoprene bearings. ■

### EXPRESS QUANTITIÉS

- Concrete: 13,000 $m^3$
- Steel for reinforced concrete: 980 tonnes
- Prestressing steel: 185 tonnes

### PARTICIPANTS

- **Owner:** Querétaro State town planning and public works department.
- **Design:** Euro Estudios, SA De CV.
- **Main Contractor:** Freyssinet de Mexico, SA De CV, Freyssinet SA (Spain).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**1. In some areas, the installation of drains and temporary surcharge have been sufficient to consolidate the soil.**

**2. Preparation of soil to be treated using the Menard Vacuum atmospheric consolidation method.**

**3. An impervious membrane covering the backfill combined with a drain and pump system to create the vacuum.**

SOILS/**CA MAU POWER PLANT**

# 240,000 m² of express soil treatment

**Within a one year time period, the combination of two methods (Menard Vacuum and vertical drains with surcharge) enabled Ménard Soltraitement to consolidate the land on which the Ca Mau (Vietnam) power station will be built.**

APPROXIMATELY 360 KM SOUTH OF HÔ CHI MINH CITY, a power plant is under construction near the village of Khanh. Bordered by the Cai Tau river, the site chosen for the construction of its two 750 MW units covers more than 161 hectares and required improvement works over an area of 240,000 m², consisting of highly compressible soil made of very soft clay. Taking into account the construction schedule of the buildings and the lead times, the work was split into six areas, in which Ménard Soltraitement used two techniques: atmospheric consolidation (Menard Vacuum process) and vertical drains with temporary surcharge. "Atmospheric consolidation was used in the areas that we had to treat quickly, that is, in less than one year from the installation of the first drain and the final fill removal," explains Yann Beliard, a Ménard Soltraitement engineer. "The total volume of water extracted from the soil using 27 pumps represents some 465,000 m³ with soil settlements between 3 and 4 m," adds Marc Lacazedieu, managing director of Ménard Soltraitement. Once the excess backfill is removed, the improved soil is 1.50 m above than its original natural elevation and its maximum bearing capacity is 10 tonnes/m².

All of the areas of the first section treated by Menard Vacuum were delivered to the civil engineering teams in June 2006, and the second section was handed over in November.

Following this success, Hervé Abt, former project manager with VINCI Construction Major Projects, joined Ménard Soltraitement to head up the office opened in Saigon to expand the soil treatment business in the Vietnam-Cambodia area. ■

## PARTICIPANTS

- **Owner:** Petrovietnam Hanoi Vietnam
- **Project Manager:** Lilama Hanoi Vietnam
- **Main Contractor:** Campenon Saigon Builders
- **Specialist Contractor:** Ménard Soltraitement

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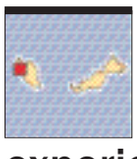
STRUCTURES/**PENANG BRIDGE**

# Cable replacement without interrupting service



**A specialist in new structure cable-staying, Freyssinet also has proven experience in replacing the stay cables of structures in service. Recent example on the Penang Bridge, Malaysia.**

ON THE WEST COAST OF MALAYSIA, the only fixed link between the peninsula and the island of Penang is a 13.5 km cable-stayed bridge (8.5 km of which is over water) comprising a cable-stayed span of 225 m. From February to October 2006, Freyssinet was involved in the replacement of two stay cables on the south-west tower, in which the monitoring system installed by Advitam (VINCI group) had detected failures. "Installed in 1985 (see box), these stay cables were replaced by the latest-generation Freyssinet 37-strand, 85 m long HD2000 models," says Pascal Martin-Daguet, Freyssinet site director. The first phase consisted of installing a pair of temporary cables to take up the load of the existing stay cables for the duration of the work, which took place without disrupting traffic (60,000 vehicles per day). All of the equipment (temporary stay cables, anchor components, etc.) used in 2005 for the replacement of the first stay cable on the same tower could be re-used.

The replacement firstly required

**Since 2002, Freyssinet has replaced 15 stay cables using its state-of-the-art anchoring system.**

slackening and then cutting the existing stay cables. This operation took place at deck level using a patented Freyssinet system that allows for the stay cable to be cut in complete safety simply using a circular saw.

### Boring the deck and the tower

The cables are then cut at the top part of the tower and these 9-tonne elements are lowered to deck level using an SL-12 strand jack fixed to a platform installed on the tower and travelling crabs on the temporary cables – another patented Freyssinet system. The deck and the tower then had to be bored over lengths of between 3.60 m and 4.50 m and a diameter of 365 mm in order to release the anchoring systems – a delicate phase that had to be entrusted to a specialist Australian company with a special machine for this purpose. After this, the new anchors and Freyssinet HD2000 stay cables could be installed.

Finally, all the Freyssinet teams had to do was transfer the loads to the new stay cables and remove the temporary anchors and cables. "It was a well managed operation," says Pascal Martin-Daguet "as Freyssinet has already replaced 15 stay cables since 2002." ■

### PARTICIPANTS

- **Owner (concession holder):** Penang Bridge Sdn. Bhd
- **Project Manager:** UEM Builders.
- **Specialist Contractor:** Freyssinet PSC - Freyssinet APTO JV.

## The old and the new

**Installed in 1985, the original cables of the cable-stayed span of the Penang bridge are made up of 7 to 10 bars with a diameter of 32 mm or 36 mm and a length of 12 m, connected by couplers and embedded in mortar, all protected by 7 mm thick metal tubing. Fifteen were replaced by Freyssinet stay cables and their latest-generation HD2000 anchoring systems.**

STRUCTURES/**TIDAL BASSIN BRIDGES**

# Shotcreting in Washington

**Acting as general contractor, Freyssinet LLC, the Group's North American subsidiary, repaired two reinforced concrete civil engineering structures in the Washington Monument district, the largest project of this type it has ever undertaken.**

SITUATED AT THE HEART OF THE FEDERAL CAPITAL, the National Mall is a vast park that extends from the Capitol, to the east, to the Lincoln Memorial on the banks of the Potomac river, to the west. Adjoining this park is the Tidal Basin, constructed in the XIXth century to regulate and improve river shipping and linking the Potomac and the Washington channel. On each side of this area of water are two road bridges equipped with lock gates: The Inlet Bridge and the Outlet Bridge. "The concrete of these structures was considerably damaged. With our experience in structural maintenance and repair, we won the repair contract by proposing a shotcrete solution for an area of more than 500 m$^2$, the grouting of the cracks and making good where necessary," says Baruch Gedalia, production manager at Freyssinet LLC, the Group's North American subsidiary.

### Corroded concrete

Built on the Potomac side in 1909, the Inlet Bridge is the smaller and older of the bridges. With five reinforced concrete arch-beam spans, it is 55 m long and 16 m wide and accommodates two lanes of traffic in each direction. "The structure was corroding, essentially due to concrete carbonation in the beams," explains Baruch Gedalia. The Freyssinet LLC teams worked to remove the damaged parts of the arches and repair them with dry process shotcrete. 200 linear meters of cracks were also injected with epoxy resin grout. The entire operation could be performed easily from a platform supported by horizontal tensioned cables designed by the Freyssinet LLC.

The newer and larger Outlet Bridge separates the Tidal Basin from the Washington canal. This 70 m long, 19 m wide structure has three spans and accommodates four lanes of traffic. The work, which is currently ongoing, consists of treating and repairing the concrete in the tidal area, some of the concrete webbing of the submerged section and the piers and abutments. "The major problem with this structure was the repeated freeze-thaw cycles. The porosity of the concrete allowed water to penetrate which, with the frost, caused successive spalling," continues Baruch Gedalia. In this part of the basin where the water is as deep as 4 m, access to the work area required the installation of a cofferdam to bring the water level to 1 m. The cofferdam was made using old concrete wall form panels anchored into the concrete apron existing under the water. Here too, a platform was installed on horizontal tensioned cables. The system was supplemented, however, by intrados-fixed hangers due to the large spans between the piers. ■

**PARTICIPANTS**

- **Owner:** Federal Highways.
- **Main Contractor:** Freyssinet LLC

SOILS/**MARQUETTE INTERCHANGE**

# Local history


**In Milwaukee (United States), on the shores of Lake Michigan, the use of original motifs on the Reinforced Earth structures of a large interchange is an opportunity to recall a page of local history.**

AT THE SAME TIME AS RENOVATING ITS HISTORIC CENTRE, the town of Milwaukee (Wisconsin) has launched a project on its outskirts to rebuild the Marquette interchange, first built in 1968, which serves as the gateway to the State at the Illinois border. The occasion saw the use of an original consultation approach between the parties involved in the project and the general public so that, as is frequently the case in the United States, characteristic regional motifs could be incorporated into the structure. "On this type of structure with "local cultural sensibilities", the bearing structures such as the retaining walls and the abutments could be shaped, sculpted and coloured to recall the local identity, culture or history," says Alex Abraham, Midwest regional manager of subsidiary Reinforced Earth Co., "which enabled us to give the structures a high visual impact at little cost."

### At the heart of a consultation approach

The Reinforced Earth Co. engineers assisted the Wisconsin Department of Transportation, the Milwaukee Transportation Partners design firm and the contractors Walsh Construction Co. and Marquette Constructors, LLC in the different phases of the project, including feasibility studies, geo-technical analyses, structural design, drawing up of construction plans, supply of materials, etc. A number of reinforced earth systems (retaining walls with metal mesh facing and precast concrete panel walls) were used to meet the structural and aesthetic specifications of the project. The solution proposed by Wisconsin Department of Transportation. for the Reinforced Earth side walls and abutments of the Fond du Lac Avenue roadbridge, for example, incorporated motifs sculpted from precast concrete recalling that in the past, this road was one of the main routes used by Afro-Americans fleeing the southern states in the XIXth century. ■

### PARTICIPANTS

- **Owner:** Wisconsin Department of Transportation.
- **Consultant:** Marquette Transportation Partners, LLC.
- **Main Contractor:** Walsh Construction Co. (north section) and Marquette Constructors, LLC (central section and western section).
- **Specialist Supplier:** Reinforced Earth Co.

SOILS/**WEEKHAWKEN TOWN HOUSES**

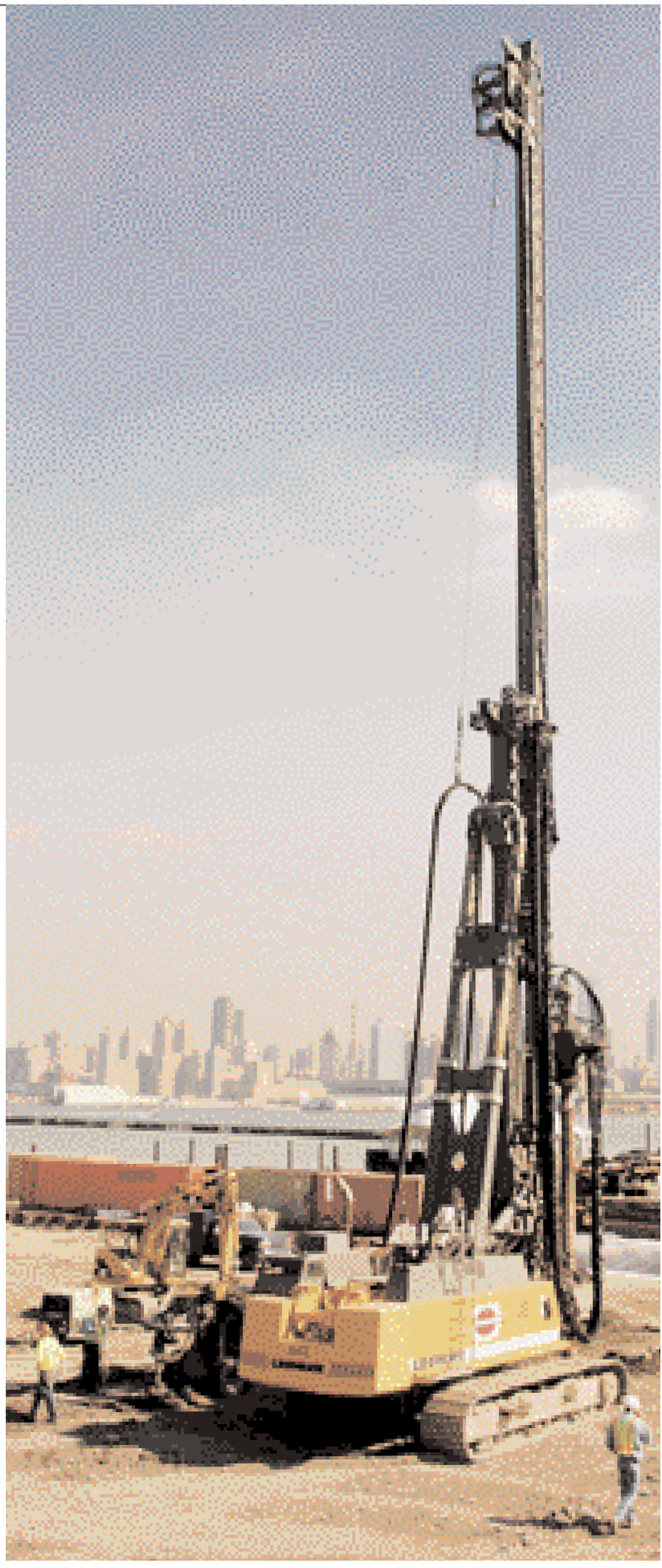
# 2,100 of CMC in town

**Facing the Manhattan skyscrapers (United States), DGI-Menard is currently installing controlled modulus columns (CMC) for the foundation supports of a prestigious residential complex.**

ON THE BANKS OF THE HUDSON, in Weekhawken (New Jersey), a property development project will soon see the construction of four groups of luxury town houses on the site of an old port terminal of approximately 180,000 ft2. "The foundation soils required consolidation," explains Frédéric Massé, assistant managing director of DGI Menard, "and our proposed turnkey treatment using controlled modulus columns (CMC) won out over a pile-supported structural slab solution." To strengthen the foundations of the courtyards, slabs-on-grade and footings of the future buildings, 2,100 of CMC will be installed. This will require deep drilling down to between 75 and 90 ft in very soft soils consisting of clayey and organic alluvium and anchor the cmcs into a solid bearing layer consisting of granular glacial material. "To carry out this deep-drilling," explains Gary Corwin, "we chose a Liebherr 255 platform with a capacity of 95 feet. The exceptional dimensions, weight and capacity of the equipment led us to adopt draconian safety measures." During the preparation phase, nothing was left to chance, so that the design requirements were fully met in terms of the allowable bearing capacity and long term settlements. DGI-Menard used the finite element analysis method in order to define the maximum load, the diameter of the CMCs and the treatment grid for the entire site. The novel nature of the operation did not hamper productivity, which was sustained by the regular supply of grout and the experience of the operators. "In six weeks, we have managed to complete more than 20% of the work," said Mike Carey, New Jersey project manager at DGI-Menard, in mid-October.

### The most complex project

The company itself was very pleased with this performance, given the project's luxury label, its highly visible urban location and the design and implementation difficulties that made this probably the most complex project DGI-Menard has ever undertaken. Another reason to be proud: two load tests were performed to the satisfaction of the client and the production is ahead of schedule. Work should therefore be completed during the first quarter of 2007, ahead of its contractual completion date. ■



**CMC: A TECHNIQUE THAT RESPECTS THE ENVIRONMENT**

**Controlled modulus columns (CMC) are normally installed using a special displacement auger. The displacement auger is screwed into the soil to the desired depth and then retracted without spoil. The ground is pushed laterally instead of being brought up to the surface by the auger flights. Grout or mortar is then injected into the soil through the centre of the hollow auger so that a column of cemented material is formed. Since this technique involves neither driving nor vibration and creates no appreciable spoil, the environment is unaffected.**

SOILS/**MADRID RING ROAD**

# Demonstration of expertise along the Manzanares

**Patrick Bernasconi, chairman of the FNTP (French National Federation of Public Works) and Bruno Dupety, chairman of Freyssinet (on right) on a site visit.**

**Tierra Armada, the Group's Spanish subsidiary, is involved in the re-development work on the Madrid ring road (Spain), where it is providing its Reinforced Earth and pre-stressing expertise, particularly for the cut-and-cover structures.**

SINCE 2004, THE SPANISH CAPITAL has seen work of titanic proportions that will make its ring road, the M30, some 100 km long, with 56 km underground. Designed to improve traffic flow and help prevent air pollution and the contamination of the Mazanares river running along the western side of the city, the project incorporates the construction of interchanges, housing and the creation of green spaces and pedestrian and cycle paths. Tierra Armada,who have been working on the project since 2005, are particularly involved in the south-west section, where the six traffic lanes will be taken under the river over a distance of 7 km. "This area is divided into two parts," explains Salvador Lorente, managing director of Tierra Armada: "One to the south, where two 16 m tunnelling machines (currently the largest in Europe), will dig out two three-lane galleries and the other to the west, where cut and cover tunnels will be built - a very delicate operation since traffic flow must be maintained."

### Reinforced slabs and panels

"Between March and December," continues Salvador Lorente, "we produced and delivered 3,500 m² of 30 cm-thick reinforced slabs to redirect the waste and rain water drains for this area. At the end of 2005, we also designed and supplied 1,900 m² of panels for three Reinforced Earth abutments forming part of the temporary structures used to divert the traffic."
During October 2006, Terre Armée Internationale's Spanish subsidiary was working in the riverside area, more specifically on the Prague Bridge-San Isidro Bridge and Segovia Bridge-Paseo Marqués de Monistrol sub-sections, for which it is producing, delivering and installing prestressed beams and post-tensioned slabs to cover the false tunnels. The project was particularly demanding. Not only did beams with close-jointed lower shoulders have to be supplied in order to obtain a completely flat ceiling, but the most stringent European fire-resistance standards also had to be complied with. "To meet this requirement and create a ceiling with fewer beams, we designed new beams with a wide lower shoulder," says Salvador Lorente. 15,000 m of prestressed beams were thus being installed on the Segovia Bridge – Paseo Marqués de Monistrol section. 1,300 m² of 40-cm thick post-tensioned slabs, designed to cover the underground entry and exit slip roads, should also have been installed by the end of October. ■

STRUCTURES/**BONNY ISLAND LNG TANK**

# 428 tonnes of prestressing

ON THE BONNY ISLAND GAS FIELD (Nigeria), Freyssinet has been supplying and installing the prestressing for a sixth 43 m high liquefied natural gas (LNG) tank with a diameter of 61 m since December 2006. Once the Plyduct sheaths have been put in place, 184 13C15 cables (equivalent to 108 tonnes of strands for the vertical prestressing and 320 tonnes for the horizontal prestressing) and 270 19C15 anchors will be installed on the tank. ■

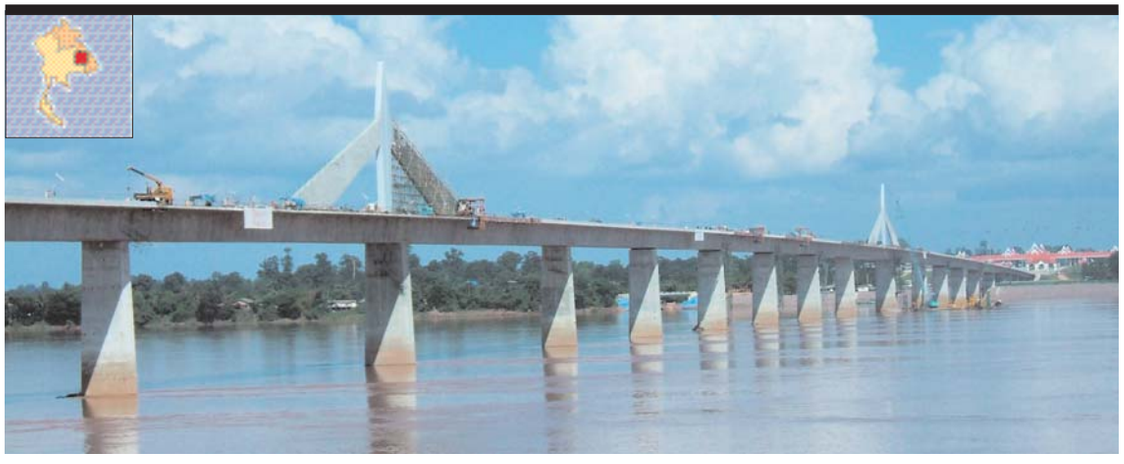
STRUCTURES/**ARRÊT-DARRÉ VIADUCT**

# For comfort

ON the A64 NEAR LHEZ in the Hautes-Pyrénées (France), Freyssinet has replaced the expansion joints on the Arrêt-Darré viaduct. Designed to improve driver comfort on the structure, the work took place from the end of August to mid-November 2006. A total of 40 m of WP 200 joints was installed. ■

STRUCTURES/**THIRD MEKONG RIVER BRIDGE**

# A new link between Laos and Thailande



MORE THAN 500 KM DOWNSTREAM OF THE VIENTIANE BRIDGE (Laos), a new bridge over the Mekong, level with Savannakhet, forms the link between Laos and the Thai province of Mukdahan, approximately 700 km northeast of Bangkok. With work having started at the end of 2003, the bridge opened in December 2006 and is the key element of a vast priority development project carried out by the Greater Mekong Sub-Region (GMS). This cantilevered structure with precast segments, except for the approach spans which were cast in-situ, is 1,430 m long and comprises 28 spans. Freyssinet supplied and installed 1,410 tonnes of steel for the structure's internal and external prestressing. ■

STRUCTURES/**STYLO MATCHMAKER BUILDING**

# 60 years of protection

IN NORTHAMPTON, south-east of Birmingham (United Kingdom), everyone knows the Stylo Matchmaker Building, built in 1900 and home to a shoe factory for many years. Comprising a steel framework and decorative brickwork facades, one of which is decorated with a Sassuolo tile facing, the building has suffered the ravages of time; due to rusting, its brickwork was cracked and had shifted at the contact points with the steel structure.

In 2005, a significant renovation campaign was launched to redevelop the site for residential use, and the contracting authority asked CCSL, Freyssinet Ltd's corrosion specialist subsidiary, to install a lasting protection system on the building. "We provide a complete service that includes the surveys, the supply and the installation of the cathodic protection," says Jim Preston, director of CCSL. "We therefore identified 40 separate "anodic zones" that correspond to the building's 40 steel columns. For each one, coated titanium discrete anodes were installed in recesses made in the brickwork from the inside of the building. This work could take place alongside the renovation works. A cathodic connection installed on the steel structure and a state-of-the-art electricity supply system completed the protection."

The supply system also has additional functionalities so that its operation can be monitored at all times, with reference electrodes, a remote monitoring device and a report printing function. "With this system," assures Jim Preston, "the structure will have optimal corrosion protection for the next 60 years…" ■

**PARTICIPANTS**

- **Owner:** Nottingham Housing Trust.
- **Architect:** Oxford Architects.
- **Consultant engineer:** Gifford.
- **Project Manager:** Lindum Stugeon Contractors Ltd.
- **Specialist Contractor:** Freyssinet/CCSL.

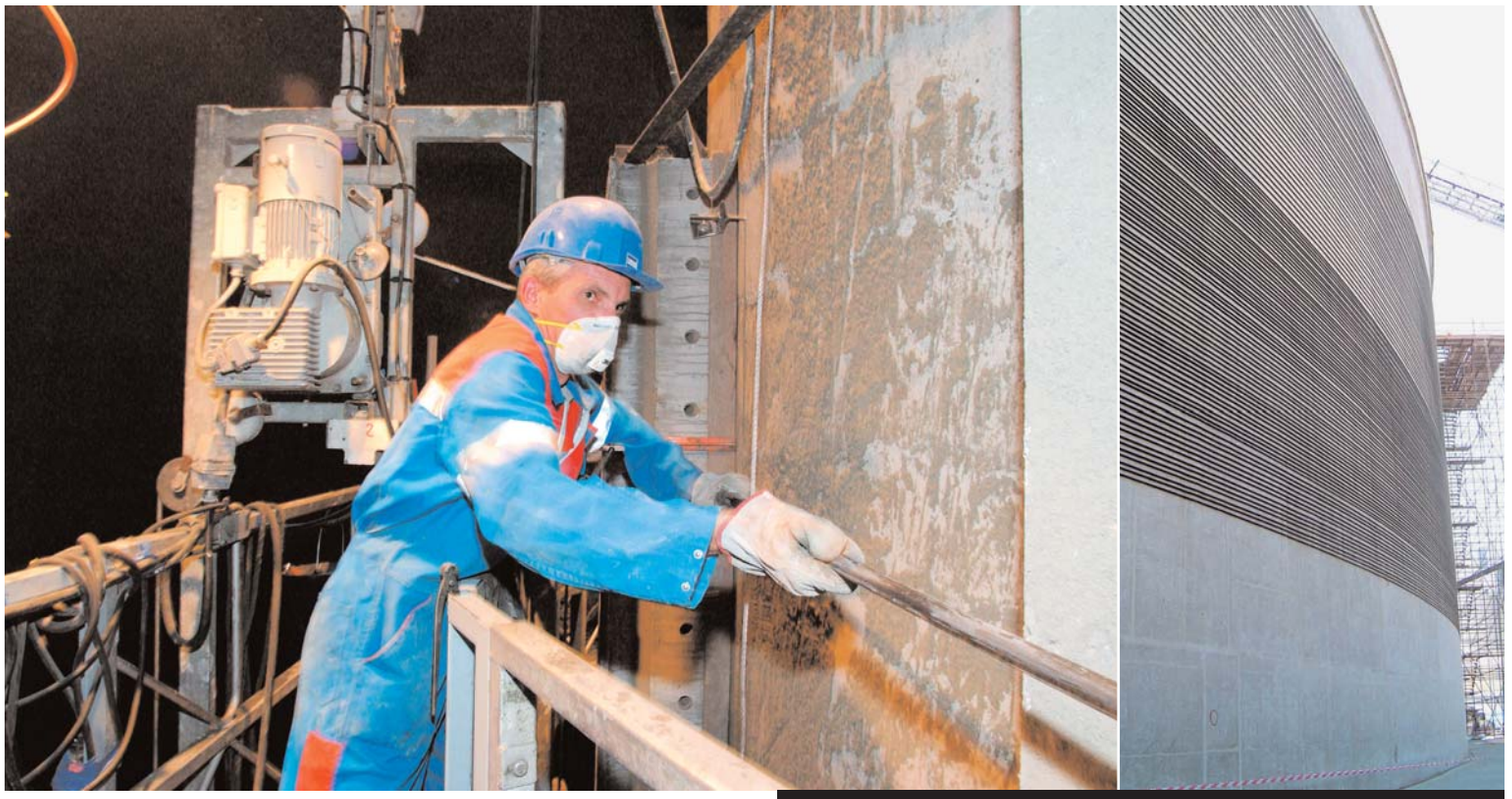
SOILS/**REMEDIATION OF THE MAYFIELD SITE**

# A ground water barrier wall

IN NEW SOUTH WALES (Australia), 180 km north of Sydney, Austress Menard has won the contract to design and build a soil-bentonite wall to prevent the pollution of the Hunter River on the edge of the site occupied by the former Newcastle steelworks. The site, which was active from 1912 to 1999 and on which up to 6,000 people worked, was officially declared a contaminated area by the environment agency, particularly a 35 hectare section corresponding to the location of the blast furnaces, four coke oven batteries and the by-products area, contributing 90% of the water pollution. After business ceased and the ancillary areas were closed, an international tender for the remediation of the land launched by the Regional Land Management Corporation (RLMC) was awarded to Austress Menard. Its solution of confinement by a quick-to-install, proven and attractively priced soil-bentonite wall was preferred to the competing solutions of cement grout or deep soil mixing walls.

Work on a 1.5 km long vertical wall with a depth of 25 to 50 m therefore began on the periphery of the site to cancel out the hydraulic gradient between the river and the contaminated area, thereby substantially reducing the inflow of pollutants into the water. This system will be completed by the addition of a horizontal sealing layer and the creation of slopes and drainage networks to minimize rain-borne contamination. In early 2005, Austress Menard had already built a structure of this type in Tempe, near Sydney airport, to prevent the contamination of a canal by landfill site leachate. ■

# ADDITIONAL PRESTRESSING: A MADE-TO-MEASURE REPAIR AND STRENGTHENING TECHNIQUE



**Additional prestressing consists in adding external stresses (above right, to a circular structure) to modify the stress state of an existing structure. Combined with other techniques such as carbon fibre fabric (TFC®) or shotcrete, additional prestressing can be used for structural alterations in a wide variety of situations.**

Prestressing, Freyssinet's historical business, is a rare example of a process that can be applied to both new and existing structures. Known as additional prestressing in the latter case, "this technique, which implements specific systems, is used to strengthen or repair structures of all types. We are approached both for our design capabilities and ability to offer variants, and also as a contractor during invitations to tender," explains Fernand De Melo, head of the Freyssinet France technical department.

### Bowstring or belt

In practice, additional prestressing can be applied not only to prestressed structures, but also to masonry or metal structures, industrial steel frames and even the wood frames of private houses. The textbook case is a civil engineering structure with creep deformation. To overcome this deformation phenomenon, which affects the structure several decades after it is built, under the effect of its own weight and use, a counterforce is exerted on the structure at the points subjected to the principal bending stresses. For a bridge, installing additional prestressing consists of anchoring cables to the two ends using sheaves and generating 'upward' forces on the structure using deviators placed on the underside of the deck. Although additional prestressing acts in the same way as a bowstring, it can also act as a belt in other situations. This is the case for circular structures such as silos, tanks, water towers (cylindrical only), where the forces applied by the cables encircling the structure offset the stresses to which the walls are subject under the pressure of the contents or due to under-sizing.

In these applications, additional prestressing uses specific systems such as circular prestressing X anchors, greased sheathed strands and other products such as Freyssibar prestressing bars.

Despite the installation flexibility of additional prestressing and its large "toolbox" we should not forget its complexity. "When faced with a structure for which we have no plans or data, we have to redo the calculations for the structure, taking into account the regulations in force when the structure was built, so that we can determine the existing non-prestressed and prestressed reinforcements. The strength of the concrete, for example, is a very important criterion that must be analysed, in addition to the residual prestressing for a prestressed structure. In summary, sufficient prestressing must be installed to account for all of the loads, but not so much that the structure is damaged. At the same time, the regulatory requirements (BPEL or Eurocode) that weren't in force when the structure was built must also be complied with. Compared with new prestressing, additional prestressing requires longer and more complicated calculations and a true engineering approach," says Fernand De Melo. ■

# SPAIN: FIRM FOUNDATIONS FOR OVER 30 YEARS

**In Spain, 1970-2000 will perhaps be seen as a Spanish version of France's "Thirty Glorious Years", a period of unprecedented innovation-conducive development that enabled Freyssinet to consolidate its traditional business and launch its repair and soil treatment activities.**

## FREYSSINET SA

Freyssinet SA has come into being twice. After being formed in 1972 to install the prestressing for the Vandellós nuclear power station, it was taken over in 1975 by Proyectos de Ingeniería Civil SA, which itself was partially purchased by MZOV soon after. Successively becoming Cubiertas y MZOV, Cubiertas, Necso and finally Acciona Infraestructuras, the new entity approached Freyssinet International, with which it shared half of its shareholders, leading to the renaissance of Freyssinet SA. During the 1980s, the company concentrated on prestressing and stay cables and was involved in prestigious projects. In 1991, it moved into rehabilitation and enjoyed growth that gradually enabled it to open offices throughout the country.

Organised on the basis of five sites - San Sebastián (North), Barcelona (Catalonia), Valencia (the Levant), Seville (Andalusia) and Madrid (Centre), today Freyssinet SA has 230 employees and splits its business into 2 key areas: products and services (prestressing, stay cables, construction methods, soil improvement, road bearings and expansion joints) concentrated in Madrid, and general contracting work, mainly rehabilitation, carried out by the regional offices. "One of Spain's particularities," explains Tomas Palomares, director of Freyssinet SA, "is how work differs depending on the region, which is reflected in each office's specialisation. In the south and the Levant, we do a lot of work on structures that could be considered restoration work. In the north, however, our business is centred on bridge repair work or lifting work to change bearings." Although the balance of business fluctuates between new work and rehabilitation, the subsidiary is most proud of the development of prestressed flooring, thanks to the work of the company's technical department and sales teams since 1992. "The construction of the Aldaya shopping centre in Bonaire (near Valencia) and the new Madrid Barajas airport terminal, undertaken in 2000, constituted a real turning point for the country in this field," believes Tomas Palomares. "Through its dynamism, the name Freyssinet is still synonymous with prestressing…but now in floors."

1. Salvador Lorente, managing director of Tierra Armada SA.
2. Tomas Palomares, managing director of Freyssinet SA.

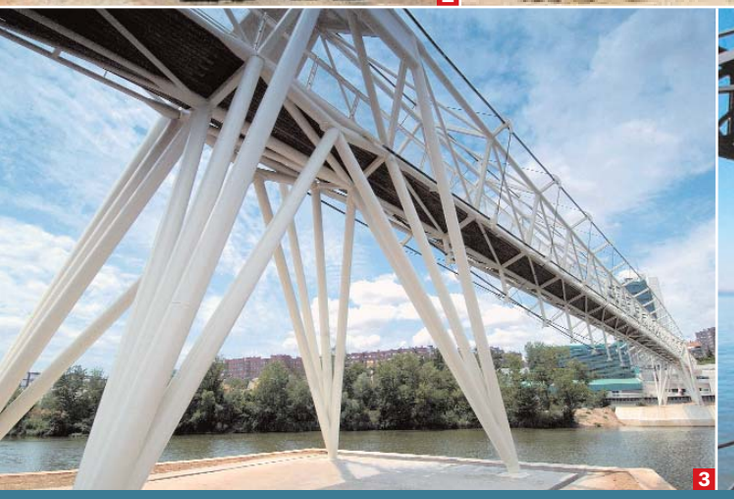
## SOIL IMPROVEMENT

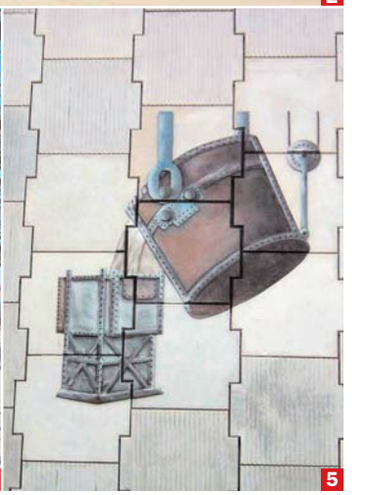
The day after the takeover of Ménard Soltraitement in September 1999, the Freyssinet Group deployed its new offering in Spain. Using a variety of techniques, the company carried out a string of projects for the construction of civil engineering structures, motorways and railway lines. For this activity, which was still so new to Freyssinet SA, but already had some fine references (Arroyo Culebro water treatment plant and ring road in Madrid, architect Ricardo Bofill's Hôtel Vela in Barcelona, etc.), there were many synergies with the French entity Ménard Soltraitement. In addition to setting up a new network of clients and partner engineering firms, introducing this new business into Spain required repeated education and explanation of soil improvement techniques that were hitherto unknown in many sectors of the Spanish market. "Launching and maintaining an ongoing soil improvement business requires work that is often difficult, but with very satisfying results. Freyssinet is gradually becoming a name that is synonymous with professionalism and expertise on the geotechnical and soil improvement markets in Spain," says Teresa Pérez, head of Freyssinet's soil improvement department.

### PROFILES

**Freyssinet SA**
- **Workforce:** 230 employees
- **Managing director:** Tomas Palomares

**Tierra Armada SA**
- **Workforce:** 150 employees
- **Managing director:** Salvador Lorente





**1. Beam precasting specialist Tierra Armada SA supplied and installed 78 Artesa beams on the high-speed railway line between Toledo and Moncejón.**

**2. Soil treatment prior to the construction of a water treatment plant near San Martín de la Vega (Madrid).**

**3. On the walkway of the Valladolid Science Museum, the Cohestrand design options have been used to spectacular effect.**

**4. Freyssinet SA undertook the complete rehabilitation of the Río Tinto wharf, Huelva, in 2004.**

**5. Architectural motifs on a Reinforced Earth retaining wall on the Cruces interchange near Bilbao.**

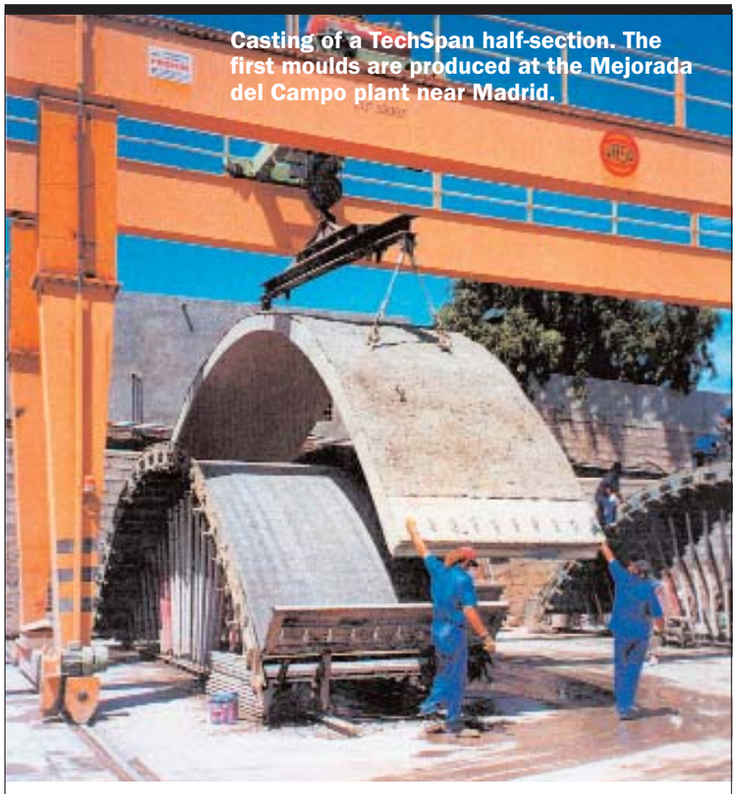
## TIERRA ARMADA SA

Also formed in 1972 and also based in Madrid, Tierra Armada SA immediately launched its Reinforced Earth retaining wall solutions on the Spanish market, but waited until 1976 before building its own production plant. In the mid-80s, this plant enabled it to provide its clients with precast concrete walls "requiring the same production equipment as the Reinforced Earth panels," says Salvador Lorente, director of Tierra Armada SA. With the addition of three-pinned precast arches to its product portfolio, the company began the construction of a new plant in 1992, equipped with heavy lifting gear. However, the construction boom during this period, which carried Tierra Armada SA along in its wake, experienced a considerable slowdown between 1993 and 1995. The company used this economic climate to diversify into precast beams. A first casting bay was installed in 1996, with a second four years later. "We had to be able to produce a large number of beams in quick time to meet renewed structural construction demand," continues Salvador Lorente. The company progressively improved its equipment and designed a new product in 2002: the Artesa U beam for the construction of the Madrid ring road. Since 1997, Tierra Armada SA has also developed the concept of mobile production, which consists of precasting elements in situ. At the end of November 2006, the company had produced more than one hundred 160-tonne beams and 4 230-tonne beams for the construction of a railway structure with hyperstatic spans near Monovar (Alicante).

With 150 employees, Tierra Armada SA has expanded its business to the Canaries, where it has been working regularly since 1999; it also provides support to its Portuguese neighbour, Terra Armada, with expertise and products and the results of research and development work. ■

# TECHSPAN: arches for the modern world

**Launched more than 20 years ago by Terre Armée, TechSpan arches provide an innovative solution for the construction of buried, hydraulic, road or rail structures, and meet increasingly complex requirements.**



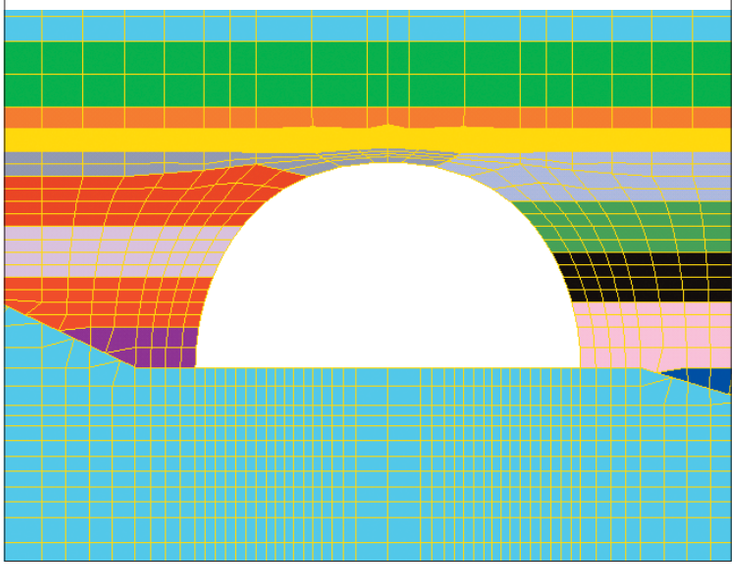
Casting of a TechSpan half-section. The first moulds are produced at the Mejorada del Campo plant near Madrid.

**1983** The history of TechSpan precast arches begins in Spain in around 1983, when Terre Armée undertook to enter the specific market of underpasses and drainage structures. The TechSpan concept is simple: precast reinforced concrete half-arches are placed on foundations and support each other by pressing against each other at the crown. In practice, the casting of the elements, particularly the moulds, presented some difficulties. After several months of testing at the Mejorada del Campo plant, near Madrid, a first system of steel shuttering panels connected by rubber joints was produced. The process was underway and continued to improve.

**1985** Even though the first tests had scarcely been conducted, and the first mould had not been produced, a structure had already been sold in Galicia! Two prototype moulds were produced and despite difficulties (fragility of the moulds), two sections were cast and dispatched to site several days later. This very first arch had a span of 6.20 m, a rise of 5.00 m, a thickness of 0.20 m and a length of 13.90 m linear metres. The first 100 arches were then built in a space of three years.

**1986** 34 structures, still of modest dimensions, were built during this year. Some, however, had curve alignment problems. The construction of an arch at the El Ferrol bus station in Galicia was a first in the history of the process, due to the length of the structure (220 m) and its very pronounced curvature. This was also the first time a transverse section had to be calculated with extremely asymmetric loads, due to the location of one of the platforms on the arches.

**1987** The calculation method reached a turning point with the first large-dimension railway structure (length of over 20 m, span of 12.50 m and rise of 8.50 m), which required the use of the finite element method. In parallel, structural design and sizing software was developed, incorporating complex behaviour models in an attempt to obtain the best possible simulation of the real behaviour of the backfill material. This has been perfected over time.

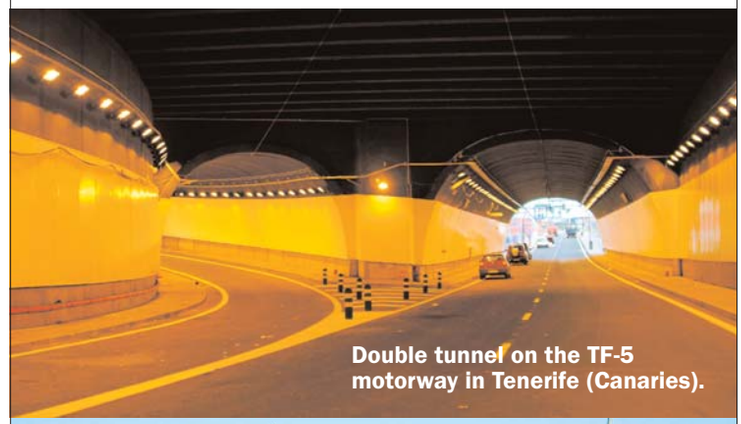


Reinforced Earth spandrel walls on the Buladelah bypass (Australia).

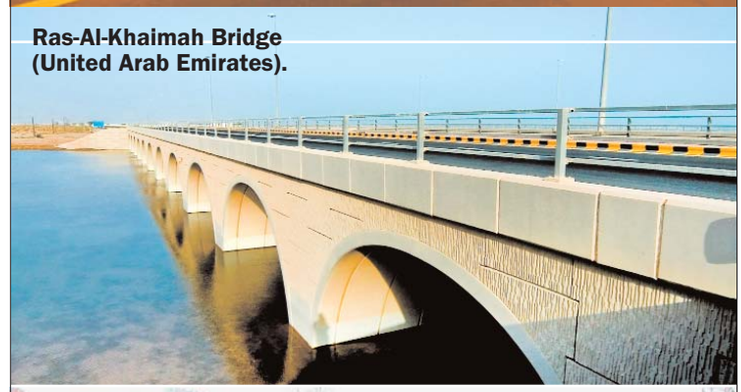
**1996** The finish of the structures changed too. Initially, concrete spandrel walls were cast in situ, then they were precast, and then they were replaced by Reinforced Earth retaining walls. 1996 saw the perfecting of the oblique cut ends solution, necessary to interconnect the half-arches and attach them to the foundations.

Oblique cut ends near Leon (Spain).

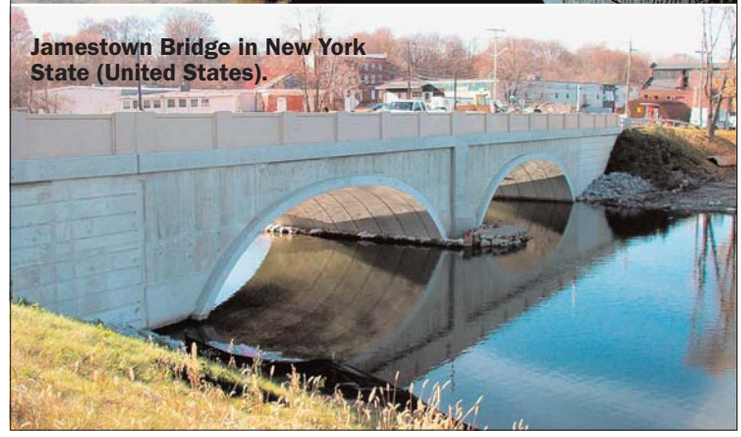
**2000** Emerging in the 1990s, the cut-and-cover market became established and structures began to reach impressive lengths. In 1995, the Montecelo tunnel in Galicia exceeded 500 m. In 2000, two exceptional structures were built: the La Horadada tunnel on the Alicante-Cartagena motorway, nearly 2 km long, and an urban structure more than 1 km long on the TF-5 motorway in Tenerife (Canaries), attached to which are a number of arch junctions. In 20 years, TechSpan arches have undergone significant changes, with their dimensions constantly increasing and with horizontal spans of more than 20 m, rises of more than 10 m and backfill cover heights over the arch reaching up to 50 m above the crown. In Spain alone, more than 1,000 structures have been built. Placed end-to-end, they would create a TechSpan arch nearly 60 km long! TechSpan arches are also used in civil engineering structures.



Double tunnel on the TF-5 motorway in Tenerife (Canaries).



Ras-Al-Khaimah Bridge (United Arab Emirates).



Jamestown Bridge in New York State (United States).

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