# Soils&Structures

THE FREYSSINET GROUP MAGAZINE

**FOCUS** PRESTRESSED CONCRETE BRIDGE CONSTRUCTION IN FLORIDA

**REALIZATIONS** BRIDGE OVER THE ORINOCO A SECOND BRIDGE ACROSS A GIANT RIVER

**HISTORY** EXPANSION JOINTS

N° 223 First half 2006

## MÉNARD SOLTRAITEMENT

## High-performance solutions for industrial buildings


Freyssinet

Reinforced Earth

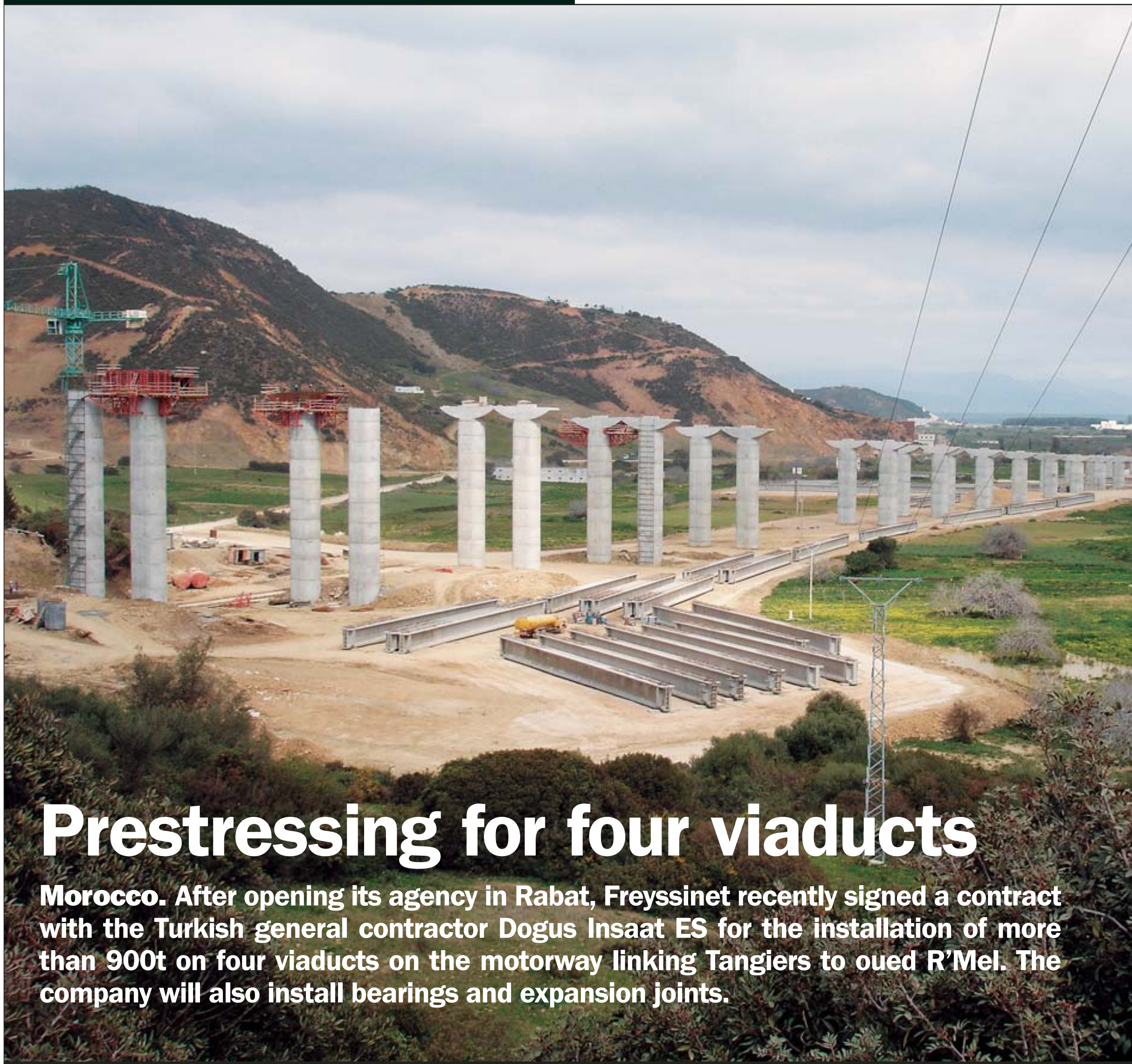
MENARD SOLTRAITEMENT

# CONTENTS









# Prestressing for four viaducts

**Morocco. After opening its agency in Rabat, Freyssinet recently signed a contract with the Turkish general contractor Dogus Insaat ES for the installation of more than 900t on four viaducts on the motorway linking Tangiers to oued R'Mel. The company will also install bearings and expansion joints.**

# Prestressed skyscraper

**Australia.** The Eureka Tower, which has just been completed in Melbourne in the Australian state of Victoria, is one of the world's tallest residential buildings (300m, 88 floors). Another special characteristic of this structure is its prestressed concrete floors. Selected for the supply and implementation of the required equipment in June 2002, the Group's Australian subsidiary, Austress Freyssinet, has just completed its mission.

# Strengthening of the Gagnac bridge

**France.** The Gagnac bridge by which the RD63 crosses the River Garonne in the Dordogne has recently been strengthened using carbon fibre fabric (TFC). Built in 1963, this viaduct, which makes use of prestressed beams and independent spans, has a total of five spans and measures 181.50m in length and 8m in width. To complete its work without interrupting the traffic, Freyssinet had to install large-scale mobile scaffolding to access the underside of the bridge. At the same time, all the bearings and expansion joints were replaced.

## A large-scale project in the Land of Smiles

**Thailand.** Initiated by the King himself to ease traffic congestion within the metropolis of Bangkok, the Industrial Ring Road project involves developing a new six-lane arterial road. Having completed prestressing installation on a number of slip-roads and interchanges (over 3,800 tonnes of steel), Freyssinet and its Thai subsidiary are gearing up to install the stay cables for the SOBRR bridge, between the towns of Bang Pli and Suk Sawat. Boasting a length of 950m, the structure has a 500m centre span stayed by 168 yellow-coloured cables.

## 450 express stone columns

**France.** It took Ménard Soltraitement just two weeks in March to strengthen the ground of a planned 8,000m² low-rise housing area in Montmagny (Val-d'Oise) using a system of stone columns. The 450 stone columns were installed by a single team in unstable ground composed of silt and sand.

## High-power strengthening

**United Kingdom.** In Dartford, near London, Ménard Soltraitement has installed 3,000 controlled modulus columns, at depths of between 11 and 14m, to strengthen the soil under a future road to be built over backfill (2 to 7m above the current ground). Since the site is partially located under a high-voltage line, Ménard Soltraitement has designed a special mast which is only 10m high and which uses extensions to reach the appropriate depth.

## Reinforced Earth repair

**Spain.** The Ajabo Bridge at Adeje on the TF-82 road in the South of the island of Tenerife collapsed last February. This incident affected a road carrying 15,000 vehicles a day, thus causing major traffic congestion. Tenerife's Cabildo (municipal council) awarded the contract for the repair work to Tierra Armada, the Spanish subsidiary, and the company erected a Reinforced Earth wall in charcoal-coloured brickwork to a height of 12 m at its highest point, in just six weeks.

## Inauguration of a new agency

**Morocco.** On 29 March in Rabat, in the presence of numerous representatives of general contractors, design offices and local customers, the Group celebrated the establishment of its new Moroccan subsidiary, Freyssinet International & Compagnie Maroc, which has been trading since autumn 2005.

## 72 stay cables on the menu

**Russia.** Freyssinet has just won a contract for modelling the Serebryany Bor bridge, located in the Moscow region, as well as for the supply and installation of the 72 stay cables required. Situated in the Silver Woods to the west of the Russian capital, this unusual structure has a span of 410m and a metal arch of 102m in height (5,000t), the very top of which will house a restaurant.

## A two-year site

**United States.** In the state of New Jersey to the north-west of New York, Ménard Soltraitement is currently undertaking dynamic compaction work to improve the ground (400,000m$^2$) and is installing 60,000 vertical drains as part of the EnCap Golf project. Scheduled to take place over a period of two years, this project is the prelude to one of the most ambitious development programs currently being undertaken on the other side of the Atlantic, comprising the construction of a golf course, hotels, housing and a shopping centre on a protected Meadowlands site.

## Four firmly anchored cranes

**United Arab Emirates.** Freyssinet Gulf recently signed a subcontracting agreement for the supply and installation of threaded Freyssibar prestressing bars to anchor the bases of four cranes in the port of Jebel Ali in Dubai. 184 Freyssibar bars measuring 2.2m in length and 50mm in diameter have been installed and tensioned in the four bases.

## TechSpan arches on the A89

**France.** Terre Armée and Tierra Armada SA have just completed the construction of two hydraulic structures using TechSpan arches on the A89 motorway near Thenon, Dordogne. The two arches, respectively 4.50m and 4.13m high with a span of 7.30m and 6.26m, each measure 130m in length and are composed of 220 prefabricated TechSpan components.

## Visit to Ling Ao

**China.** In March 2005, Freyssinet signed an agreement with the principal constructor Huaxing Construction Company (HXCC) for the supply of prestressed elements for the containment vault for two 900 MW PWR reactors as part of phase 2 of the Ling Ao nuclear power project. During a visit organized by Freyssinet on 23 March, HXCC's representatives and Group Chairman Bruno Dupety were able to observe the progress made at the site: after one year of effort, the foundation of reactor building No. 1 is ready for concreting, while that of reactor building No. 2 is currently being reinforced.

## 77,400m$^2$ won back from the sea

**Saint Lucia.** In order to host the next cricket world cup in 2007, the little Pigeon Island, in Saint Lucia in the Caribbean, has started construction of a marina comprising slips for yachts and prestigious hotels. The project required the creation of a 77,400m$^2$ platform, reclaimed from the sea by means of a dredging operation. Ménard Soltraitement is responsible for reinforcing this area using vertical drains and dynamic replacement.

## Rehabilitation of a water treatment plant

**France.** Freyssinet has rehabilitated unit 3 of the Saint-Thibault-des-Vignes water treatment plant (Seine-et-Marne) where the acidity of the processed liquids had severely damaged the concrete of the walls of the biological treatment tanks and the supply pipe. Following a thorough cleaning of the structures, preparation of the substrates by sandblasting and passivation of the steel components, the treatment tanks were strengthened by means of dry process shotcrete of a thickness varying between 4cm in the submerged area and 18cm on the underside of the slab. A fibreglass reinforced acid-proof epoxy coating was then applied to the walls. To complete the rehabilitation of the unit, the 1,500m$^2$ of supply pipes were then wet coated.

## Cables and anchors for a silo

**Turkey.** In Ankara, Freyssinet's Turkish subsidiary Freysas was involved in the construction of a silo of 36m in diameter and 68m in height at the Bastas cemetery. 40t of tendons and 152 anchors were supplied and installed.

## Inauguration on the Karoon

**Iran.** Constructed in the south-west of the country on the Karoon river, Iran's first cable-stayed bridge was opened on 1 May in the presence of the Iranian Minister for Public Works. The structure has two pylons and is 822m long (including a 300m main span) and 14m wide, with a mixed concrete and steel deck which is cable-stayed by Freyssinet. The company has also installed the bearings, expansion joints, Freyssibar prestressing bars and Transpec seismic dampers.

## Expansion of an LNG terminal

**United Kingdom.** In January, Freyssinet performed the prestressing of the shells of three identical new liquefied natural gas (LNG) storage tanks at the methane terminal on the Isle of Grain on the south-east coast of England. Their total capacity is 570,000m$^3$.

## As good as new

**Australia.** Built in a number of phases between 1896 and 1912, Sydney's Trades Hall House remained in its original state until it was closed in the 1980s. Since becoming the new head office of Unions NSW, it has benefited from a renovation conducted, in particular, by Austress Freyssinet that worked on the façades of the building. After cleaning the façades with non-chemical and non-abrasive products, the Australian subsidiary's teams tackled their complete restoration, replacing the damaged stone and brick, balusters and flashing and treating the cracks with epoxy resin injections. The rendering on the main façade was renovated in the same way and the wooden sash windows and a number of light wells inside the building were restored.


Freyssinet
EUROVIA BETON


# Express work below the track

**On 13 May of this year, Freyssinet and its subsidiary JMB Méthodes installed a rail bridge close to Châteaudun (France) using the Autoripage technique to allow the Brétigny-Tours line to cross the deviation of the RN10 road. With a length of 40m, this structure which weighs 2,050t was moved 18.4m using a system of cables equipped with two 1000t jacks in just two hours.**

LARRY SESSIONS, P.E.

# Prestressed Concrete Bridge Construction in Florida (USA)

**Florida is a leader in the design and construction of prestressed concrete bridges. Larry Sessions, Assistant State Structures Design Engineer at the Florida Department of Transportation (FDOT), shares his knowledge of prestressing and new developments in the prestressing market.**

**Larry Sessions, P.E., has 37 years of Civil Engineering experience encompassing bridge design, bridge inspection, bridge analysis and rating, bridge maintenance and rehabilitation, and bridge construction. In his current position as Assistant State Structures Design Engineer for the State of Florida he is involved in the review and checking of consulting engineers' designs of major bridge projects, as well as being in charge of the design of bridge projects and special projects.**

**Soil & Structures - Could you define the prestressed concrete construction market for bridges?**

**Larry Sessions.** In Florida, our primary use of prestressed concrete is for pretensioned bridge components which are used for simple span bridges. Post-tensioned bridges are usually more suitable for long span applications – greater than 150 feet (46 m). Marine structures which are accessible by barges are good candidates for post-tensioned bridges. Post-tensioned bridges are also well suited for interchanges requiring continuous curved ramps. Post-tensioned bridges normally require the building of a casting yard, which can cost as much as a million dollars (US). If you are constructing "I" shaped girders the casting yard is less expensive. If you are constructing box shaped girders the casting yard is more expensive. Therefore, the project's scope-of-work has to be a large enough to merit the expenditure of a casting yard.

**In the U.S., Florida is a leader in the use of concrete for bridges in comparison to other states where steel is mainly implemented. How do you explain this situation?**

The precast and prestressed concrete industries are highly developed in Florida because constituents used in concrete are an abundant natural resource. Therefore, concrete structures are generally more economical. Florida's climate is semi-tropical and urban development is predominately along the coastline. This salty environment causes rapid corrosion, making concrete the logical choice. Also, Florida has a long coastline with large number of long water crossings suitable for barge access and handling of heavy concrete structural members.

**What is your opinion about PT evolution over the last 10 years?**

At the Florida Department of Transportation (FDOT), we recognize post-tensioning as a versatile system suitable for a wide variety of structural solutions. However, post-tensioning requires considerable attention to detail to insure a quality product. With the use of external tendons, we have experienced a limited number of tendon failures. Most of the problems that occurred in the past were due to poor quality plastic ducts and improper grouting. In time, the ducts became brittle due to oxidation and environmental degradation exposing the steel strands to the corrosive environment. These tendon failures can be attributed to both poor workmanship and poor product specifications. Action has been taken by the FDOT on a broad front to correct the quality issues we experienced in the past. The new FDOT specifications require trained personnel to perform all installation, grouting and inspection of post-tensioned systems. The post-tensioning specifications have been completely revised to require approved materials with proven performance. Also, field testing is required

«At the Florida Department of Transportation (FDOT), we recognize post-tensioning as a versatile system suitable for a wide variety of structural solutions.»

**At Freyssinet, all post-tensioning material is produced and tested in-house and conforms to the highest international PT standards. The implementation is insured by specialized teams that are trained and certified.**

**In order to improve durability of the PT components, Freyssinet developed the Liaseal Coupler, a device designed to connect prestressing ducts used with precast segments made with match-cast joints. It is compatible with the different precast phases and makes ducts sufficiently watertight to satisfy international requirement (particularly the British TR47 standard). This device was implemented for first time on the American State Road 789 (Ringling CSW) project in Florida.**


***fib* CONGRESS**
**From June 5-8, 2006, Freyssinet participated in the second *fib* Congress (fédération internationale du béton) in Naples, Italy. The Group presented its latest prestressing development and repair solutions, including the Anatolian Motorway site.**

to insure the delivery of a quality product. The specifications require post-tensioning systems to be a tested and approved as a complete system suitable for use in a particular application. Only approved and tested pre-bagged grouts are allowed. In general, we at the FDOT believe the past deficiencies noted with grouted tendons can be corrected and the use of replaceable tendons is unnecessary for most applications. In Florida, the use of post-tensioning in the construction of bridge structures will continue to have a bright future.

**What should be improved in the future to increase the durability of prestressing?**
It is the opinion of the FDOT that the processes we have implemented have corrected the durability problems we experienced in the past. The last pressing problem for the FDOT is the development of a pressure rated duct coupler to be used on ducts passing through segment joints. The Freyssinet Corporation is complemented for its developmental work with the Liaseal segment duct coupler. The Liaseal coupler could be adapted to meet the FDOT requirements in terms of air tightness. The FDOT specification for post-tensioning specifies that a complete system composed of all components be supplied as a unit. The FDOT has qualified post-tension systems now, but at this time we do not have approved post-tensioned systems with segment duct couplers.

**There is a big interest today in the U.S. for fast track bridge replacement and the ability to add lanes in urban areas with minimal impact on local traffic and businesses. How does it affect bridge construction in Florida and in the U.S.?**
Florida is fast becoming a very urban state with a congested roadway system. The interruption of service in urban areas caused by construction must be minimized in order to reduce congestion and user costs. The use of prefabricated bridge components for both superstructure and substructure will increase, resulting in more prestressed components. Florida has more segmental constructed bridges than any other State in the US. The use of accelerated bridge construction including the use of SPMTs (Self-Propelled Modular Transporters) to construct bridges off-site and quickly place them into service will increase. In fact, we just recently finished our first accelerated construction of a bridge using SPMTs. The Graves Avenue project is the first time this technique has been used to replace a bridge over an interstate in the U.S. The use of SPMTs allowed the FDOT to build the bridge off site and move the entire bridge into place, saving about four months construction time and reducing the impact to drivers.

**What materials will be used in the future of prestressed concrete?**
Polymer and nano-cements may be used to improve grouts. The chemistry and crystalline structure of these cements is different than the regular Portland cement. These new cements are stronger and have much lower permeability resulting in less chloride, water and other contaminants penetrating into the grout. ■

# HIGH-PERFORMANCE SOLUTIONS FOR INDUSTRIAL BUILDINGS

**More economical, faster and also more flexible than conventional foundation systems, Ménard Soltraitement's processes for soil reinforcement and ground improvement are suitable to all soil conditions and are being used more often amid the increasing scarcity of so-called "good" sites and the changing nature of the structures they support.**

"Ménard Soltraitement has no competitors," asserts Serge Varaksin, the company's deputy general manager. "All the other companies offering soil reinforcement and ground improvement services specialize in applying to all situations specific processes which they thoroughly understand.
However, Ménard Soltraitement systematically attempts to identify and develop the most appropriate solution for each individual case. As a result, the ten or so processes that we have developed now allow us to target and perform any project irrespective of the nature of the ground..." Less than 50 years after the company was founded, this specific capability seems to come directly from the vision of a man: the company's founder, the engineer Louis Ménard, who, as emphasized by Serge Varaksin, was a "man with a vision, a scientist and businessman combined, whose two aims in life were the improvement of the pressuremeter and the development of new soil improvement techniques."
Following the invention of dynamic compaction, which contributed to the company's breakthrough in the late 1960's by saving 30% to 50% compared to conventional foundations on sands, Ménard Soltraitement continued its research & development effort to broaden the scope of its technologies to all soil conditions (see boxed text p.13). A number of major innovations followed, such as the Menard Vacuum atmospheric consolidation process (1988), controlled modulus columns (1994), and so on. These developments opened up new markets in Europe where the large-scale projects of the company's early years – airports, motorways, port installations, railway lines, water treatment plants and, more generally, everything that Ménard Soltraitement refers to as infrastructure, are gradually giving way to new types of developments.
According to Philippe Liausu, assistant general manager of Ménard Soltraitement, "In France, and in other developed European countries and the United States, economic developments and the reorganization of trade have resulted and continue to result in the development of large industrial buildings and, in particular, in the construction of storage and transportation platforms which cannot always be built on good soils due to the increasing challenges of urban development."
During this same period, international business has taken over in terms of new infrastructures as a result of geopolitical developments, fluctuations in growth and state investment. "These markets are currently expanding in central and eastern Europe," continues Philippe Liausu. At the same time, the company has a long history of working with the booming petrochemical industry and related sectors where we are well known, in particular in projects involving liquefied natural gas (LNG) terminals and tanks, a field which is currently booming as the price of oil increases and resources become increasingly scarce." ▸▸

A systematic attempt to identify the most appropriate solution.

Soil consolidation using dynamic compaction on the M7 motorway (Hungary).


42,000 meters of controlled modulus columns installed at Marly-la-Ville (Val-d'Oise) prior to the construction of a 26,000 m² storage and transportation hub.

**The various techniques developed since the 1970s allow the company to target and perform any project at any type of site.**

In the port of Kwangyang (South Korea), Ménard Vacuum consolidation process was used in the development of 350,000 m² reclamation.

# Storage and transportation hubs: already a quarter of the company activity in France

"During the 1970s, France witnessed the first wave of warehouse construction around the outskirts of its cities and since the mid-1990s we have seen a second wave of large-scale development – it represents a quarter of our activity in France – associated with the relocation of production resources and the reduction of transport times which demand the reorganization of distribution and storage capabilities," states Jean-Marc Jaugey, a project engineer responsible for business development in France. These new storage and transportation hubs, used for every conceivable product (fresh foods, furniture, frozen products, electronic equipment, spare parts for vehicles and so on), all share the same general scheme: a surface area of between 5,000 and 20,000m² (tending to increase), a limited height and an average load capacity of 5 t/m². These are therefore structures for which soil improvement techniques are the solution of choice when deep foundations are three or four times more expensive. However, these developments have increasingly stringent performance specifications in terms of differential settlement. In other words, even where an overall settlement of the structure, i.e. "absolute settlement", is permitted (this should generally be less than 2 or 3cm), "differential" settlement should not exceed 1/2000th (i.e. 1mm over a distance of 2m) in order to prevent any cracking at slab level.

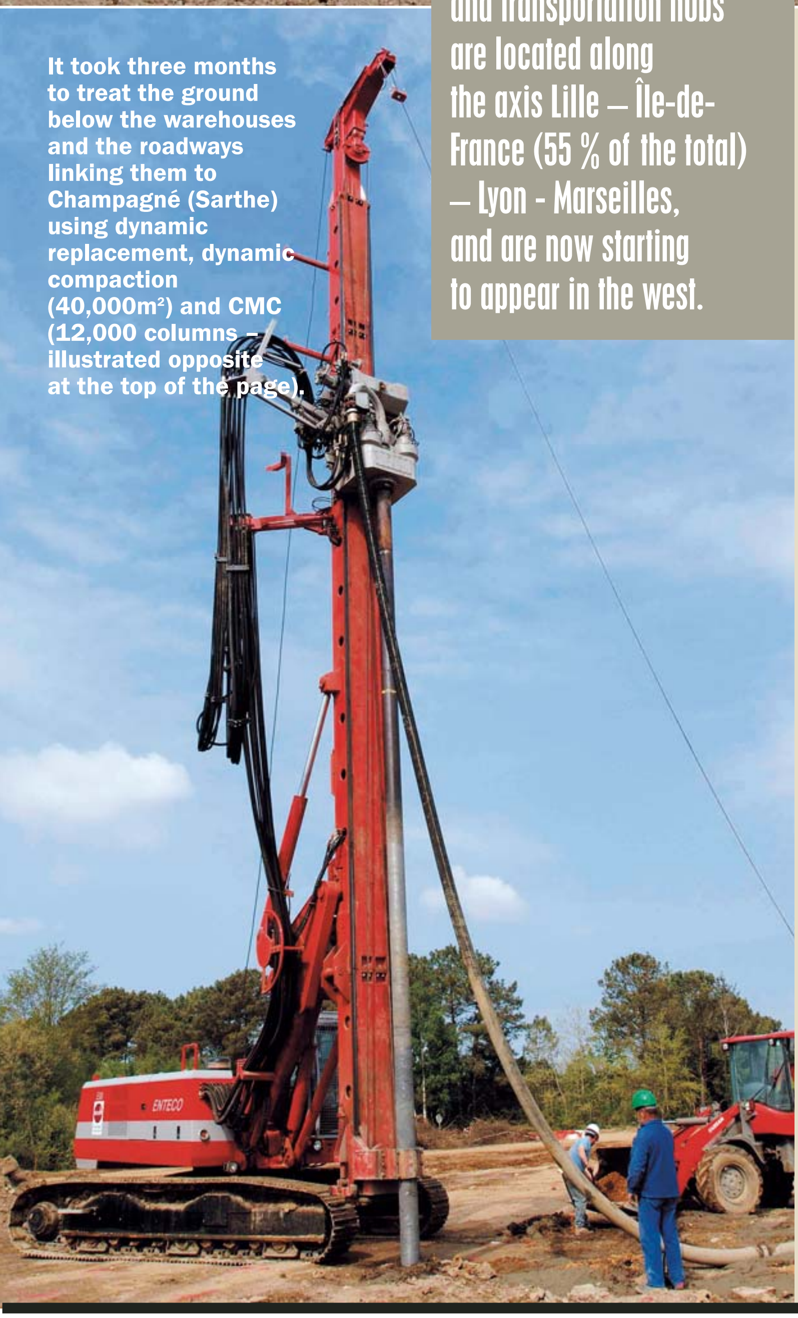
### Three solutions which are sometimes combined

Whether requested by a construction company, a general contractor, an investor or directly by a customer – there is no single format – and irrespective of the solution initially recommended by the construction manager or geotechnical engineer, the company carries out new studies on the basis of the information supplied by the customer or the site owner – geotechnical reports, project data (surface area, peak loads, distributed loads, specifications etc.) – in order to identify the most appropriate technical and economical solution and propose different types of solution for different situations. "The three techniques that are most frequently used in France are dynamic compaction, stone columns and controlled modulus columns," continues Jean-Marc Jaugey, "and we sometimes find it necessary to combine them, for example in the case of building extensions, since dynamic compaction cannot be used in the immediate vicinity of adjacent buildings due to the vibrations it causes or in response to extremely strict specifications."
This was the case for Socamaine, Leclerc's purchasing centre in western France, constructed in Champagné near Le Mans (Sarthe) alongside the Paris-Nantes high-speed rail link on the site of a former sand quarry which had been filled in with a huge range of different materials. "We worked on the site twice," recalls Benoît Pezot, the project engineer who was in charge of the operation, "initially, to reinforce 8,000m² of a 'liquid' storage area at a load capacity of 25 kN/m² together with 40,000m² of roadways and car parks and, the second time, for a 40,000m² extension for consumer goods, with a load-bearing capacity of 60 kN/m².
Two different methods were used for the first operation: dynamic replacement for the warehouse and dynamic compaction for the roadways and car parks. In the case of the new warehouse, which was completed in May this year, we chose to use controlled modulus columns which made it possible to guarantee the required performance levels by being reaching greater depths. In France, almost all the major hubs of this kind are constructed along the north-south axis," continues Jean-Marc Jaugey, "mainly in the Lille and Île-de-France regions, which account for 55% of activity in the sector, and around Lyon, Marseilles and Avignon in the south. As the 'Estuaires' motorway (Dunkirk-Biarritz) gradually comes into play, new projects are emerging in the west: in Rouen, Le Mans, Orleans and Le Havre."

CMCs can be used close to existing buildings or buildings that are under construction

For the construction of storage and transportation hubs, soil improvement techniques have become the solution of choice when deep foundations are three to four times more expensive.

Most of France's storage and transportation hubs are located along the axis Lille – Île-de-France (55 % of the total) – Lyon - Marseilles, and are now starting to appear in the west.



It took three months to treat the ground below the warehouses and the roadways linking them to Champagné (Sarthe) using dynamic replacement, dynamic compaction (40,000m²) and CMC (12,000 columns – illustrated opposite at the top of the page).

## Processes adapted to the nature of the soil and the structures


### DYNAMIC COMPACTION

Specially suited to granular soils, this process permits deep soil compacting through the creation of high-energy waves generated by dropping weights of 15 to 40t onto the soil from a height of 10 to 40m.


### DYNAMIC REPLACEMENT

Used exclusively for inconsistent surfaces, this process involves reinforcing the ground by creating columns or pillars, 2 to 3m in diameter made of highly compacted granular materials. They are installed using specialized equipment similar to that employed for dynamic compaction.


### THE MENARD VACUUM ATMOSPHERIC CONSOLIDATION PROCESS

The Menard Vacuum creates a vacuum in water-saturated soil using a patented system of air pumps and water pumps, sealed by impermeable membrane and a network of vertical and horizontal drains. The principle is based on the use of the atmospheric pressure in order to preload the soil.


### CONTROLLED MODULUS COLUMNS (CMC)

CMCs are semi-rigid inclusions of cementitious grout installed on a grid pattern throughout the site that is to be improved. They are not intended to directly support the load from the structure but to reduce the overall deflection of the soil. They are particularly well suited for high loads or organic soils with strict settlement specifications.

# International: participating in the dynamic global growth

At an international level, Ménard Soltraitement's activity is keeping pace with the pulse of the global economy and is conducted, depending on the region in question, via subsidiaries (United States of America, Australia, Germany, South Korea, Malaysia), operating agencies employing local engineers who may or may not work within the framework of a Freyssinet subsidiary (Spain, Poland) or directly from the parent company in Nozay. In particular, Pierre Orsat, export manager, is responsible for establishing or re-establishing the company in areas where it is no longer present. From the new Mediterranean port in Tangiers (Morocco) to the LNG complex in Skikda (Algeria), from the water treatment plants in Egypt to India's petrochemical terminals, the company has conducted many different studies. "We don't always notice it in France but these countries have absolutely stunning opportunities and business development programs. As for India, it relies on a different type of production – brainpower – since a million engineers graduate every year…".
Dominique Jullienne is responsible for regional activity in the Middle East. Based in the Freyssinet agency started in Dubai (United Arab Emirates) in 2004, he follows up projects initiated by Pierre Orsat on behalf of international customers while also responding to local invitations to tender. "The level of project development here is breathtaking," he states, "and we are witnessing a kind of race for infrastructure which gives the impression that the limits to investment can be pushed back indefinitely." Although it has a great level of involvement at the Ras Laffan gas terminal (see opposite) in Qatar, the company does not restrict its activities to a single site. Dominique Jullienne quickly goes through a list of some of their most striking recent achievements: a steel pipe plant in the Emirates, the Abu Dhabi corniche, a soil improvement project for sugar silos in Dubai, two projects for the Burj Dubai property development complex, including the construction of the world's highest tower (800 m), transport and distribution hubs and residential buildings in Ras Al Khaimah in the north of the Emirates, a seawater desalination plant in Saudi Arabia, and so on. "In 2004, we had around fifteen employees. Now we have 40 or 45 and our equipment resources have been boosted from two to eight cranes with the help of our parent company. But despite these investments, responding to the growth in activity which is set to climb by 50% or 60% over the 2005 level poses complex problems in terms of organization and recruitment."
In Australia, the company proposes the soil improvement techniques mentioned above and also works in other specialized sectors such as the repair of structures using the jet-grouting technique and watertight cut-off walls using the soil-bentonite wall method. ■

** System for measuring the compressibility of the soil.*

## Ras Laffan: working for the booming natural gas sector

In 2005, Ménard Soltraitement worked with VINCI Construction Grands Projets to construct a 140,000m³ LNG tank for Exxon-Mobil and Ras Gas at the Ras Laffan gas terminal in Qatar. "This installation complements the existing tanks and marks the start of a new development," explains Dominique Jullienne "since an equivalent new project is underway with the same partners and six more tanks are to be constructed between now and the end of 2007." Located at the northern end of the peninsula and 80km from the capital, Doha, Ras Laffan is one of the largest gas installations in the world and has the capacity to process the resources available to Qatar, which boasts some of the largest reserves in the world. "It is difficult to imagine Ras Laffan: a vast platform criss-crossed with networks of pipelines and housing a gas refinery, liquefaction plants, immense storage facilities and all kinds of associated activities: an industrial waste treatment plant, an electrical power station, and so on, creating an intense level of activity and involving a great number of businesses."
"On this site", continues Dominique Julienne, "the soil conditions are very poor since the ground on which the installation is to be located consists of loose sand or airborne materials (desert dust) mixed with salt down to a depth of 1.50m). Locally, this is known as 'sabkha'. Compared with conventional methods such as pile foundations, removal and replacement of the surfacial soils, the solutions proposed by Ménard Soltraitement – dynamic compaction of loose sand, dynamic replacement in sabkha-type soil – have been praised by our clients for their economical advantage (they require no cement or steel), their low environmental impact (no large-scale transportation of materials) and their speed."

"The company responds to many different studies, from Egyptian water treatment plants to Indian petrochemicals terminals."

In Hamburg, two CMC teams working in a dual configuration treated the soil of a 40,000m² storage platform in a very short time.

At an international level, Ménard Soltraitement's activity is based on subsidiaries and operating agencies using local engineers or is handled directly by the parent company.

In the capital of Abu Dhabi (United Arab Emirates), Ménard Soltraitement has been able to improve a platform of 1 million square metres using dynamic compaction.


Ménard Soltraitement has used a number of different techniques in the construction of sugar silos in Dubai: dynamic replacement, dynamic compaction and partial replacement.


Pressuremeter tests in Ras Laffan.

STRUCTURES/**BRIDGE OVER THE ORINOCO**

# A second bridge across a giant river

## At the construction site of the second bridge across the Orinoco in Venezuela, Freyssinet is demonstrating its expertise in the field of cable stays and structural equipment.

THE WORLD'S THIRD LARGEST RIVER in terms of waterflow, the 2,140km long Orinoco traverses Venezuela from west to east and has only one vehicle crossing, the suspension bridge at Angostura, near Ciudad Bolivar. Fully aware of the handicap that this internal border represents for the country's economic development, the government of Venezuela has been considering the construction of a new crossing for over 20 years. The starting gun for the project was fired on 8 May 2000, with the conclusion of a contract for the engineering and construction of a second bridge over the Orinoco between the publicly owned Corporación Venezolana de Guayana (CGV) and the local subsidiary of the Brazilian building contractors Norberto Odebrecht. The selected location is the confluence of the Orinoco and the Caroní river at Ciudad Guayana, approximately 100km downstream of the initial bridge. This strategic location will facilitate trade with the neighbouring states of Bolivar, Anzoátegui and Monagas.

The Brave design office, an association of two well-known design offices – Figueiredo Ferraz in Brazil and Lustgarten y Asociados in Venezuela (responsible for the stay cables) was entrusted with the design of the structure by Odebrecht while technical assistance during the construction phase was provided by Leonhardt Andra und Partner and independent watchdog tasks by Cowi A/S.

After signing a contract with Odebrecht for the supply and installation of the stay cables used on the bridge on 1 November 2002, the Group's Spanish subsidiary, Freyssinet SA, soon saw its service scope "increase enormously" as Jose-María Noval, the company's export director, explains. "We were asked to supply and install the prestressed components for four pylons and the central pier between the bridges, the prestressing for the pinning between the deck and the central pier, the bearings and expansion joints for the access viaducts and the main bridge, Transpec seismic devices, dampers, retaining cables on the external bridge piers and a variety of complementary operations." With a length of 3,180m, the structure comprises two access viaducts consisting of 23 and 12 spans of 60m at the southern and northern ends respectively. These surround a cable-stayed main bridge of 1,080m in length, consisting of two 300m spans above the navigation channels. The deck takes the form of a central metal caisson, 5m in height and 5.70m in width, flanked by

**A BILINGUAL TEAM** "Since Spanish is the official language of the contract and Portuguese is the main language spoken on the site," explains Jose-Luis Serra, Freyssinet's director of special structures, "the management of Freyssinet's Iberian-American Division decided to train a bilingual Spanish-Portuguese team to carry out the work." Site management was therefore entrusted to Pedro Pinto De Sousa, a Portuguese engineer, and two Brazilians, Leonardo Netto (responsible for production) and Eduardo Martins (responsible for methods and quality). This combination was particularly important at a site where the management and operating teams came from all parts of Latin America and everyone agrees that it contributed to the success of the project."

wings of 7.90m in length. It sits on 39 piers, four pylons rising to 120m and an A-shaped pier which forms the bridge's fixed point. To guarantee these structures ability to resist the power of a river which sees an annual rise of approximately 13m, the piers are seated on piles of 2m in diameter sunk to a depth of 60m. "The construction of the deck started in Brazil, in Ipatinga in the state of Minas Gerais, where the sheet steel plating and shaped sections were cut and prefabricated. These components were then transported by sea to the site where the concrete segments (12m long) were assembled," states Jose-María Noval. In the case of the access viaducts, the concrete segments were launched from abutments using a system of cables and jacks. For the cable-stayed section, only the initial segments were launched from abutments. The following segments, located above the navigation channels, were joined together in pairs to form 24m sections and then hoisted from the river as required as the stay cables were installed. In the final spans next to the A-shaped pier, the segments were assembled on a truss and then pushed into place.

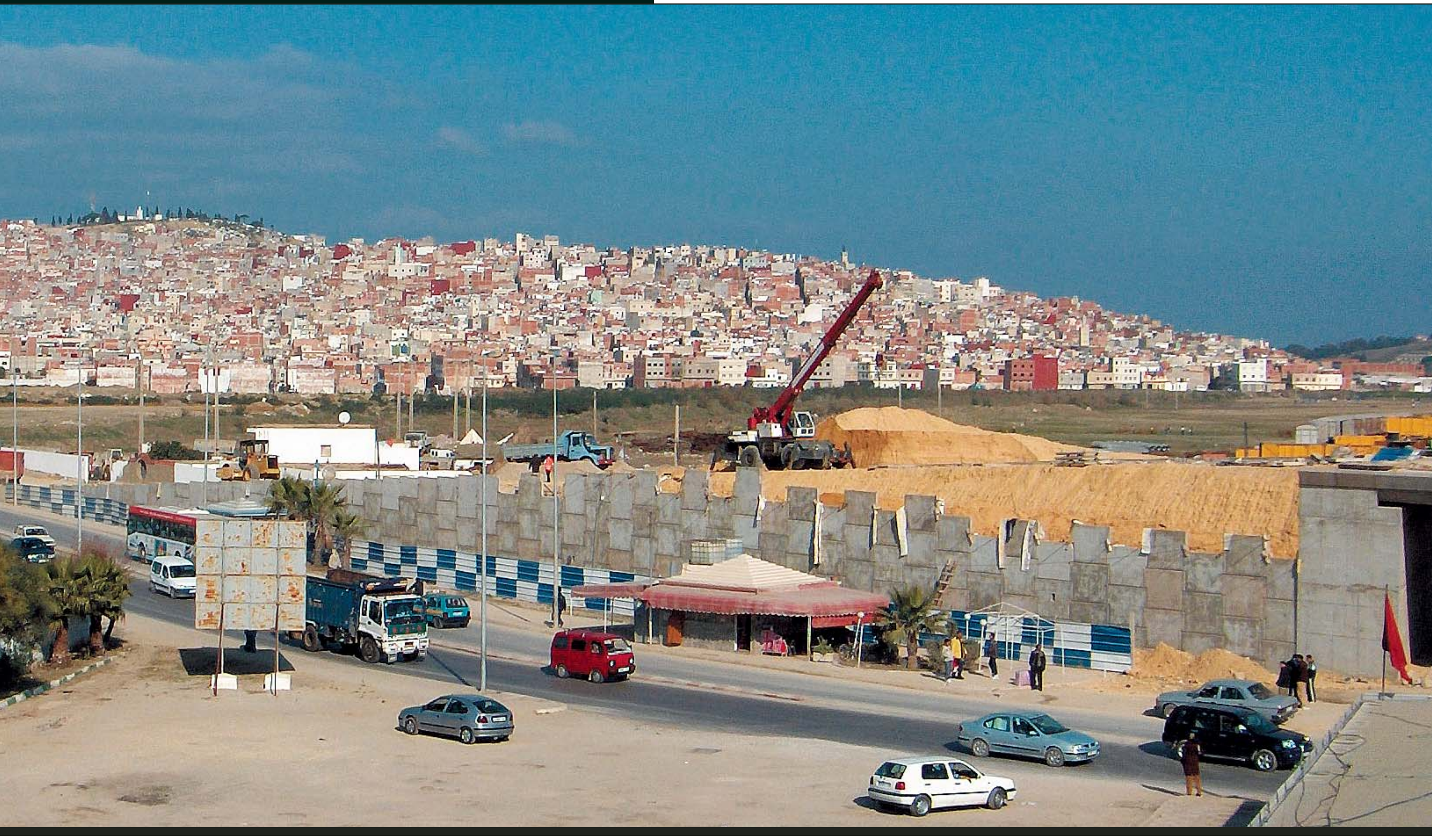
### New generation stay cables

"The installation of the stay cables was closely linked with the work involved in the construction of the deck and was performed in stages, in accordance with a procedure developed by Leonhardt Andra und Partner," states Pedro Pinto De Sousa, Freyssinet's site manager. "A dual segment (24m in length) was first hoisted and welded to the elements which had already been installed. The slab was then reinforced and the first 12 metres cast. An initial pair of rear stay cables was installed, followed by a forward pair. The last 12 metres of the slab were then cast, making it possible to install the two remaining pairs of stay cables, at the front and back." Benefiting from recent technological advances, the 176 stay cables (88 per bridge) were arranged into four parallel planes measuring between 59 and 158m in length. To absorb vibrations, they are equipped with internal hydraulic dampers (IHD) while internal radial dampers (IRD) are used for the 16 longest stay cables.

A specialist in the field of structural equipment, Freyssinet also supplied and installed all the banded neoprene bearings for the access viaducts (tested prior to the project at the University of Bochum in Germany) as well as the Tetron bearings used in the cable-stayed section. Cipec WP expansion joints and Transpec paraseismic devices were used for the connection between the various spans in the access viaducts. Finally, Freyssinet's engineers had to develop special cables to pin the deck to the A-shaped pier. ■

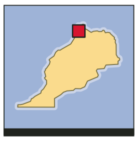
## Key figures

- 136 500m³ of concrete.
- 15 200t of steel reinforcements.
- 20 000t of steel for the construction of the deck.
- 1 400t of stay cables.



SOILS/**MALABATA SLIP ROADS**

# Freyssisol's advantages mount up



**A structure currently being built to cross the railway line close to Tangiers (Morocco) makes use of 2,830m² of Freyssisol retaining walls.**

ON THE RN2 ROAD IN MALABATA, close to Tangiers, the Moroccan national railways office (ONCF) has decided to build a structure to enable motorists to cross a railway route in complete safety. Access is provided by two Reinforced Earth slip roads with a maximum height of 9m and which support a 20m wide platform with a total length of more than 267m. The work has been entrusted to a consortium consisting of Handassa Entreprise (Casablanca) and EBB (Marrakech) which suggested using the Freyssisol system instead of geotextile planes in combination with concrete blocks. “This solution offers many advantages,” states Pierre Sery, director of Terre Armée SNC who also acts as commercial manager for the project, “such as great flexibility of assembly which makes it possible to build the retaining wall in Reinforced Earth on a highly compressible foundation soil without any damage to the facing, a good level of earthquake resistance thanks to a mechanical connection between the reinforcing mechanisms and the facing which prevents any problems at the facing, and, finally, the on-site prefabrication of the panels by the consortium which eliminates transport-related difficulties.”

### Reinforcement steel strips

The low bearing capacity of the foundation soil and calculations forecasting an overall settlement of 60cm led Terre Armée SNC to replace the foundation soil below the wall to a depth of 2m and connect the facings on either side by means of synthetic reinforcing strips. "During and after the construction of the wall, the settlement levels were continuously monitored by means of topographical measurements,” adds Pierre Sery, “and were limited to 30cm below the facing and 40cm at the centre of the backfill.”

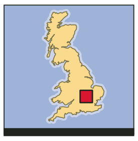
Work on the construction of the slip roads, representing a facing surface of 2,830m², started in June 2005 and was completed at the end of March 2006. ■

## PARTICIPANTS

- **Owners:** Office national des chemins de fer du Maroc (ONCF).
- **Main contractor:** Consortium Handassa Entreprise – EBB.
- **Specialized contractor:** Terre Armée SNC.

STRUCTURES/**BLENHEIM CENTER**

# The prestressing solution



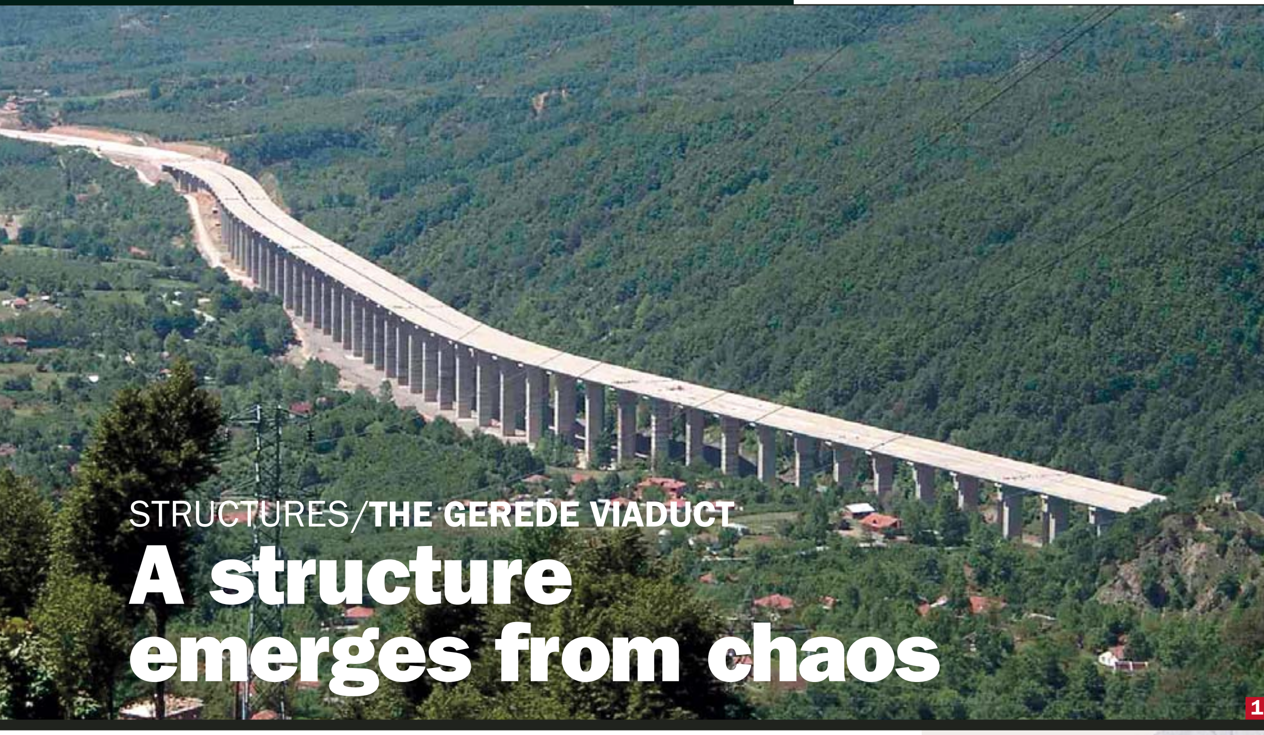
**On the huge Blenheim Center building project, built in the suburbs of London (United Kingdom), a delicate design problem has been solved by using floor prestressing.**


**By enabling to gain 400mm per storey, the prestressed concrete floor contributed to keeping the building height to within the authorized limits.**

THE BLENHEIM CENTER, LAID OUT ROUND A HUGE "PUBLIC AREA", is a mixed purpose complex of an impressive area (102,000m²) comprising a 415 place parking area, shops, cinemas, offices and 487 apartments spread over seven floors. Located in Hounslow, on the edge of Heathrow, the largest airport in Europe, between the North and South air corridors, height restrictions laid down by the airport authorities had to be complied with for the Blenheim Center as well as a right of way below ground, represented by a tunnel housing all communication and reservation information links to the new Terminal 5 at the airport. The Norwest Holst (VINCI Construction) engineers preferred to raise the whole structure 1.5m in relation to the basic design, reduce foundation depths and build the underground parking area above the tunnel, rather than divert the right of way, a costly solution. Now this alteration increased the height of the building, which consequently exceeded the permitted limit. "A 2.5m high in-fill structure had been planned between the hypermarket on the ground floor, and the apartments built above, at the time the building was originally designed." said Gavin Taylor, the Norwest Holst site manager. "So we thought of reducing the floor thickness in the apartment part, and contacted Freyssinet." In the end using prestressing, the thickness and weight of the building floors could be significantly reduced. Nearly 3.6m on the total height was gained by reducing the in-fill structure to 2m (instead of the 2.5m originally planned) linked to a 400mm gain per floor. Moreover, resorting to prestressing greatly reduced the quantity of passive reinforcement making it possible to make the building lighter compared with a traditional reinforced concrete solution, without altering the foundations. "By calling in Freyssinet onto the project and resorting to prestressed concrete floor, we have been able to adopt innovative solutions and dispassionately take up the challenge." continued Gavin Taylor. "Our cooperation has been really successful, contributing to speeding up construction, that we completed one week early." ■

## PARTICIPANTS

- **Owner:** Blenheim Center (Day & Johnson Ltd).
- **Architect** Michael Aukett Architects.
- **Consultant/Structural engineer:** SKM Anthony Hunt Ltd.
- **Main contractor:** Norwest Holst.
- **Specialized contractor:** Freyssinet Ltd.



1

STRUCTURES/**THE GEREDE VIADUCT**

# A structure emerges from chaos

**Damaged by the 1999 earthquake while still in the construction phase, a viaduct on Turkey's Anatolia motorway has been repaired using innovative methods designed and implemented by Freyssinet's teams.**

4


5

THE 450KM LONG ANATOLIA MOTORWAY linking Istanbul to Ankara has to cross the Bolu pass between Gümüsova and Gerede. In 1999, this section of the motorway, which was still under construction at the time, was affected by an extremely violent earthquake with a magnitude of over 7.2 on the Richter scale. The damage inflicted on a major viaduct was particularly severe. In its terminal phase at the time the disaster occurred, the structure comprised two decks of 2.3km each (59 spans of 40m) supported by 115 piles of a height of 30 to 50m. Each of these decks consisted of 7 prefabricated beams interconnected by a top slab continuously cast across 10-span segments. Under the effect of the repeated shocks, the deck segments moved on the pier heads and some of the beams became detached from their supports, thus making the structure totally unstable and preventing any continuation of construction work. Following initial inspections, which concluded that it would be impossible to repair the decks, the general contractor Astaldi finally proposed a solution which consisted of lifting and recentring the decks and then improving their resistance to earthquakes and operating loads. This audacious solution was chosen and the work entrusted to Freyssinet.

### Recentring the decks

Before starting the repair work, it was necessary to realign the decks. Freyssinet's first task at the site was therefore to lift and recentre the decks.

In addition to relatively conven-



**After the earthquake, certain segments of the viaduct's 2.3km deck (1) had become detached from their supports (4). The solution implemented by Freyssinet used Y-shaped tools (5) and jacks (2) to lift and reposition these components. Tendons at each pier (3) were used to transfer the load from the beams to the new bearings.**

tional equipment used to raise the ends of the segments at the level of the expansion joints, innovative equipment had to be developed by Freyssinet's Methods department to deal with the intermediate piles. A Y-shaped mechanism was developed to simultaneously support, raise and realign the structure during the longitudinal and lateral movements of the deck. Overall, 36 tools of this type, each capable of bearing 350t, were manufactured and installed (four per pier). "We were asked to work on 400 metre-long stretches, i.e. 10 spans, representing a weight of 14,000t," explains Dominique Deschamps from Freyssinet's technical department, who is responsible for the concrete division. Using this equipment, it was initially possible to raise the beams at one pier after another by approximately 5cm. The existing supports were then removed and the actual recentring operation could start. "This was one of the most delicate phases of the operation," continues Dominique Deschamps, "since it required longitudinal and transverse movements at all the piers simultaneously." Five mechanisms were therefore used to push the deck between 50cm and 1m in the longitudinal direction while other specially designed devices were used for transverse alignment of approximately 50cm. The Y-shaped mechanisms were slid onto Teflon plates resting on header beams. A final lift of 80cm was then undertaken at each pier to achieve the structure's new longitudinal profile. In total it took just 18 months for Freyssinet's 50-person teams to perform all the handling operations and realign the viaduct.

The rehabilitation and structural strengthening of the viaduct could then be started. The pier heads were refitted and any uneven areas interfering with the structure were eliminated. Cracks were injected and a certain amount of local levelling work was performed. "To guarantee the deck's longitudinal consistency, we installed prestressed crossbeams at each pier. These consisted of 19C15 or 13C15 tendons which allowed us to transfer the load from the beams to the new bearings located along the pier axis," adds Dominique Deschamps. The most badly damaged beams were strengthened using TFC (carbon fibre fabric), with strips being affixed to the underside and the sides of the beams in order to resist bending and shearing stresses respectively. The most severely damaged parts of the beams were completely reconstructed.

To complete the work, the viaduct was equipped with seismic supporting devices and the expansion joints at piers 10 and 30 were removed, thus making it necessary to strengthen the upper slab, again by TFC strips. ■

STRUCTURES/**SHA TIN HEIGHTS PROJECT**

# Technical challenge on highway 8

As part of the Sha Tin Heights project (construction of the Sha Tin section of highway 8) in Hong Kong, Freyssinet used a launching beam to install the 203 precast segments required for the erection of two access viaducts, one at the southern end (7 spans) and the other at the northern end (6 spans).

The segments were then provisionally prestressed using Freyssibar bars. Finally, Freyssinet performed the permanent prestressing and supplied and installed the structure's bearings and expansion joints. The site turned out to be a real challenge, involving significant technical constraints (6% slope of the structure, cant of 10%) and night time work in two-hour phases due to its location next to railway tracks and maintenance buildings belonging to the railway company KCRC. ■

SOILS & STRUCTURES/**HEGIGIO SUSPENSION BRIDGE**

# Double service and multiple benefits

**Austress Freyssinet and Austress Menard took part in the construction of a pipeline services bridge for industrial use spanning a gorge almost 430m deep in the Southern Highlands of Papua New Guinea**

IN ORDER TO RUN THE PIPELINE link from an oilfield to the Kubutu refining facilities in the high plains of the southeast of the country, owners Oil Search Ltd were required commission the construction of a suspended access bridge across a 470m span of the 430m deep Hegigio gorge. Designed by Kellogg Brown & Root, the structure comprises two towers – one 36.5m high at the southern end and the other 5m high at the northern end – a steel deck carrying the pipeline, the main suspension cable consisting of 86 galvanised strands as well as two restraining and wind-bracing cables attached to each side of the deck. In December 2004, the Main Contractors, Clough Nuigini, called on Austress Freyssinet and Austress Menard to construct the permanent and temporary ground anchorages, install the suspension and wind cables, launch the deck after having specified the methods, and finally, to launch the pipeline.

As the first company in the Group to commence works on site, Austress Menard was in charge of drilling, fabrication and installation of the eighteen permanent anchorages which were to stabilise the wind-bracing cables as well as the main pier cap of the southern tower. With the completion deadline being very tight, Austress Menard performed an in-depth analysis, in advance of the works, of the implementation conditions. "This enabled us to establish that the geological conditions were poor, with a limestone substratum characterised by the presence of highly to moderately fractured and disintegrated matter, combined with the likely presence of underground solution cavities, explained Greg Cooney, Australian Project Manager for the Freyssinet Group. Accordingly, we took precautionary steps which turned out to be highly effective, such as installing full length sacrificial steel casing over the length of the anchorages to overcome problems encountered with the cavities during installation and grouting of the tendons."

In order to maintain the deadlines without hindering the main program of the works (building the anchorages was on the critical path) and to forestall any problems that might arise such as production constraints or equipment breakdown, Austress Menard established an additional drill

2

3

4

**Making drill-holes and retaining cable anchors in the rocks (1). A single carrier tendon with 86 strands is drawn between the two banks (2). The main deck with its arrangement of hanger positions and wind-bracing cables, ready for the pipeline (3). Pylon and access tower on the southern abutment (4).**

rig and compressor. A further difficulty for the contractor: arranging site access, since only the southern abutment was accessible by road. All materials and equipment had to be helicoptered to the north side, including the drilling rig which was carried across the gorge without its rotary head (due to limiting weight restrictions) and reassembled in situ. "Austress Menard also had to establish a water supply to the northern side of the gorge, added Greg Cooney. A 9,000 litre tank was helicoptered in, with a stand-alone pump enabling water to be supplied through an HDPE pipe secured to the main suspension cable between the two abutments." Added to these difficulties, overcome thanks to the ingenuity of Austress Menard technicians and engineers, was the narrowness of the work platforms. This made it necessary to prefabricate all the anchorages on the south abutment and helicopter them across to their point of use, where they were installed using a special guidance tool & frame.

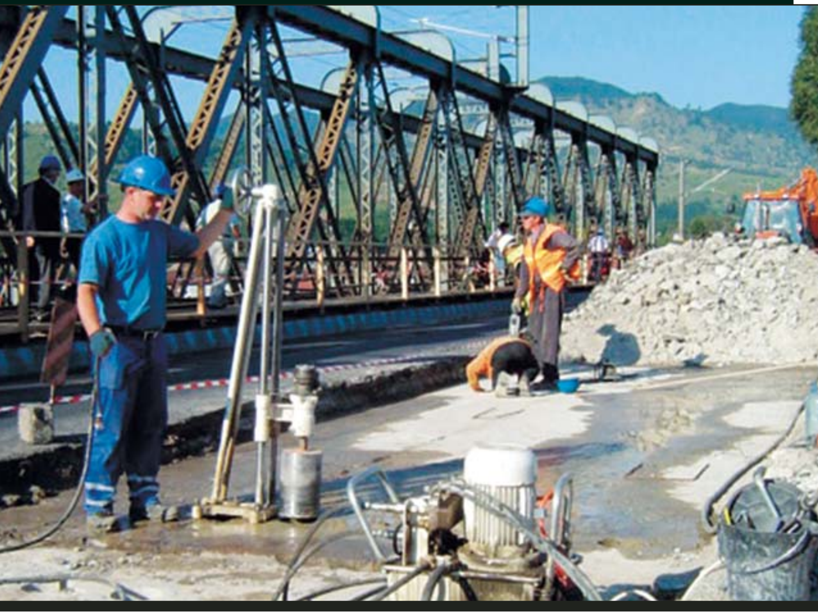
### One tendon instead of two

The Group's services continued with the construction of the bridge itself. Working with the Group's technical department based in France and the Project's Designers, Austress Freyssinet's proposal was to adopt a single 86-strand carrier cable rather than two number 43-strand cables, a solution that offered a number of advantages, in particular that of obviating the need for potentially difficult operations involving load transfer between the two cables. A 30m high temporary access tower was assembled on the southern abutment in order to facilitate the assembly of the final main tower and to fabricate and then launch the structural steel deck elements of the bridge. Suspension cables and backstays were installed using winches. A specially designed outhaul / backhaul trolley system incorporating carabiners and linked cables was installed across the gorge using helicopters to create a concertina arrangement, thus enabling the main carrier tendon to be erected strand by strand. Freyssinet's patented Isotension system was used to tension each strand individually as installation proceeded. The deck was progressively launched using two L180 launching rams supplied and operated by Austress Freyssinet. As the incremental launching of the main bridge deck progressed, the wind-cables were launched from a bank of 74 No. cable reelers and assembled with cable clamps and connecting bracing cables. The stays were eventually secured to the anchorages and stressed to achieve the desired tension and alignment for the structure.

The final stage consisted of launching the pipes. These were butt-welded at the southern abutment and installed on the footbridge in 36m sections using a winch and a single-strand ram. Congratulations go to all members of the team as all works were successfully completed due to dedication and perseverance whilst working under extreme conditions in a remote location. ■

## PARTICIPANTS

- **Owners:** Oil Search (PNG) Ltd.
- **Designer:** Kellogg Brown & Root Pty Ltd.
- **Main Contractor:** Clough Nuigini Pty Ltd.
- **Specialized contractors** Austress Freyssinet Pty Ltd, Austress Menard Pty Ltd.



**Comanesti bridge: hydraulic core sampling (left) and installation of reinforcements.**

STRUCTURES/**R14 PROGRAMME**

# Rehabilitation operation in Romania

## The Freyssinet Group is taking part in a programme to bring 14 Romanian structures into line with European standards.

R14 IS THE NAME GIVEN IN ROMANIA to the programme designed to rehabilitate 14 bridges located all around the country to bring them into line with European standards. Freyssinet is taking part: “We have just started work on the Comanesti bridge (120m long) in the north-east of the country and the Tomsani bridge (60m long) in the south-west,” says Dimitri Plantier, director of the Group’s Romanian subsidiary Freyrom which has called on the assistance of Freyssinet’s Major Projects teams to help in the venture. At Comanesti as in Tomsani, the work consists of strengthening the decks of the structures by means of longitudinal prestressing based on blocks compressed using prestressing bars. “Due to a lack of maintenance and the poor quality of the concrete used in their construction, the structures were badly damaged,” notes Marc Gonthier, Freyssinet’s manager of works at the two structures. At each bridge, work started with the demolition of the old deck and the construction of a new distribution slab. Freyssinet’s teams then applied shotcrete to repair the damaged areas or to complement the strengthening work through additional prestressing. The final stage will be replacing the bearings and expansion joints.

### Safety and quality

Since there are no alternative routes which could be used to divert traffic, the bridges cannot be closed during the work. This constraint meant that Freyssinet had to establish a very rigorous organization in order to ensure that all site personnel enjoyed safety conditions in line with the Group’s risk prevention policy. “The teams working at these sites are actually quite big,” says Marc Gonthier, “with 10 Freyrom personnel employed at Comanesti and 6 at Tomsani, complemented by the staff of small service suppliers or subcontractors which account for 26 to 32 people at Comanesti and 3 to 15 at Tomsani.” As well as safety, we also have to concentrate on quality, with our work being guaranteed by the regional inspectorate and approved analysis laboratories. Finally, environmental protection is not neglected and various measures are being undertaken to construct appropriate bankings, reconstruct waterways, strengthen the banks and piers using gabions or to construct the sites' own access routes and maintain the river beds. ■

### PARTICIPANTS

- **Owners:** National Company of Motorways and National Roads.
- **Main contractor:** Freyssinet.

## Key figures

| | COMANESTI BRIDGE | TOMSANI BRIDGE |
|---|---|---|
| **Expansion joints** | Type N50 | Type WD 60 |
| **Bearings** | 24 Neoprene bearings | 14 Neoprene bearings |
| **Reinforcements** | 68 tonnes | 19 tonnes |
| **Additional prestressing** | Sheathed greased strands: 6.2 t<br>168 tonnes of prestressing | Sheathed greased strands: 2.4 t<br>18 Freyssibar bars |
| **Shotcrete** | 2 200 m$^3$ | |

SOILS/**CHÂTEAU DE SAUMUR**

# Jet-grouting to the aid of the northern rampart

## At the château de Saumur (France), a 14th century building whose northern rampart is currently being restored, Ménard Soltraitement has undertaken work to strengthen the foundations using jet-grouting.

A FORTRESS transformed into a luxurious dwelling in the 14th century, the château de Saumur has served in turn as the residence of the Dukes of Anjou, a prison, an arsenal and, finally, after being purchased by the city in 1906, a museum. The passing of the centuries has revealed that the building is not as indestructible as it appeared. During the night of 22 April 2001, following a period of heavy rain, part of the northern rampart (50,000m$^3$) collapsed onto the land and houses situated further down the slope, causing significant damage and jeopardizing the entire northern section of the structure. Although work (cross-bracing) was immediately performed to secure the structure, reconstruction did not get underway until 2003, after funding was authorized by the Ministry for Culture and Communication – the regional department of cultural affairs of the Pays de la Loire region. It was conducted by the Regional service for the conservation of historic monuments in cooperation with the Architect responsible for historic monuments.

In October 2005, the strengthening of the foundations of the northern rampart, already in the course of construction, was entrusted to Ménard Soltraitement, the Group's soil improvement specialist, which suggested strengthening the structure by installing jet-grouting columns. In the middle of October 2005, the team set up its base at the foot of the castle. The team comprised a head of works, site manager, team manager, drilling expert and specialist in the preparation of grouts as well as manual workers. Its task was to create 120 columns bored to a depth of 12m in a period of 4 months. "The operation was greatly complicated by the configuration of the ground," says Michel Bic, a project engineer for Ménard Soltraitement, "since the production unit was located at the base of the rampart while the drill was installed about thirty metres higher up."

Undertaken in two phases, the first on the outside of the ramparts and the second inside the building itself, the work consisted of boring into the masonry, lowering the tool to the required depth and then raising it while injecting grout at a pressure of 400 bars through to the underside of the foundations. The resulting columns have a diameter of between 60 and 80cm and are positioned at intervals of 1.60m.

### A carefully monitored site

"The pace of the work," says Pierre-Yves Bellec, a site engineer for Ménard Soltraitement, "was based on the 'breathing' of the castle, in other words, its movements which, from the very start, were monitored by the site owner and Ménard Soltraitement in cooperation with Advitam." The building was equipped with a monitoring system consisting of 120 targets regularly scanned by a theodolite connected to a computer, thus making it possible to detect the slightest movement. For reasons of convenience, a remote measurement acquisition system was set up with Advitam to collect the data directly in the site office. During the second phase, conducted inside the castle, an even more sophisticated system was required to guarantee complete protection of all the areas in which the company was working.

With regard to the regeneration of the masonry, Ménard Soltraitement entrusted this work to Freyssinet's western agency at the very start of the operation.

STRUCTURES/MELBOURNE CRICKET GROUND STADIUM

# 340t of prestressed components in the stands

**In Melbourne (Australia), Austress Freyssinet performed the prestressing work for the new stands at Melbourne Cricket Ground, the country's largest stadium.**

LOCATED IN THE CENTRE OF THE YARA PARK stretching from Melbourne city centre to the suburb of Richmond, the Melbourne Cricket Ground (MCG) is the country's largest stadium and one of the most popular. The venue of the 1956 Olympic Games, it welcomes more than 3.5 million cricket lovers and Australian rules football fans every year. Eight years ago, an ambitious stadium upgrade project was launched to extend spectator capacity to 100,000, improve the view of the pitch and add a number of peripheral facilities: changing rooms, car parks, bars, and so on. “Work started on the site in 2003 and was carried out in five main phases, including the demolition of the old stands, in particular those constructed for the Olympic Games in 1956, and their replacement by new structures supported by large-scale prestressed beams. In 2002, the general contractor Grocon Construction decided to entrust us with all the prestressing work associated with these beams,” explains Andrew Mc Farlane, a works foreman for Austress Freyssinet. Freyssinet’s teams consequently supplied and installed the material, tensioned the cables (consisting of monostrands in the case of the peripheral beams and multistrands in the case of the radial beams) and injected the grout. “In total, 340t of steel were used and the work was completed in March, in time for the opening of the Commonwealth Games, exactly 50 years after the Olympics.” ■

STRUCTURES/
FOOTBRIDGE OVER RUE DE L’ÉPINE

# A natural link

AFTER EIGHT MONTHS OF WORK, Freyssinet recently completed the construction of a grassed footbridge measuring 30m in length and 10m in width over the rue de l’Épine, linking the Jean Moulin (Bagnolet) and Guilands (Montreuil) parks in the eastern suburbs of Paris. This three-span structure (two spans of 8.5m and a central section of 13m) consists of encased metal girders. Working together with Terre Armée, Freyssinet departed from the original solution and suggested building Reinforced Earth ramps to permit access to the deck. 600m² of TerraTrel and 110 m² of TerraClass walls were thus built on either side of the structure. As well as the construction of the footbridge, Freyssinet also supplied and installed the elastomeric bearings and the expansion joints. ■

SOILS/THE A71 MOTORWAY

# Mars clears a stretch of motorway in Erfurt

USED FOR THE FIRST TIME in Abu Dhabi (see S&S No. 220), the MARS system (Menard Automatic Release System) has now made its appearance in Europe, at a motorway site in Germany. “Near Erfurt, the path of the A71 motorway crosses a region of particularly unstable soil due to the random presence of voids where the gypsum has dissolved,” explains Jean-Luc Chaumeny, manager of Ménard Dyniv GmbH. These voids occur down to a depth of 15m and initially the client, namely the company in charge of the planning and construction of the infrastructure for the new länder (DEGES), was planning to either inject the soil or purge it completely. As an alternative to these extremely expensive solutions, Ménard Soltraitement succeeded in ensuring the use of the MARS system. The energy released when the mass is dropped – over 1,000t/m – is such that the voids are “broken up”. The initially planned surface area for treatment was 96,000m² but in the light of the excellent results obtained, an additional area of 40,000m² should be treated by October. This augurs a bright future for the Ménard Soltraitement process. ■


# THE RESTORATION OF HISTORIC MONUMENTS IN SPAIN

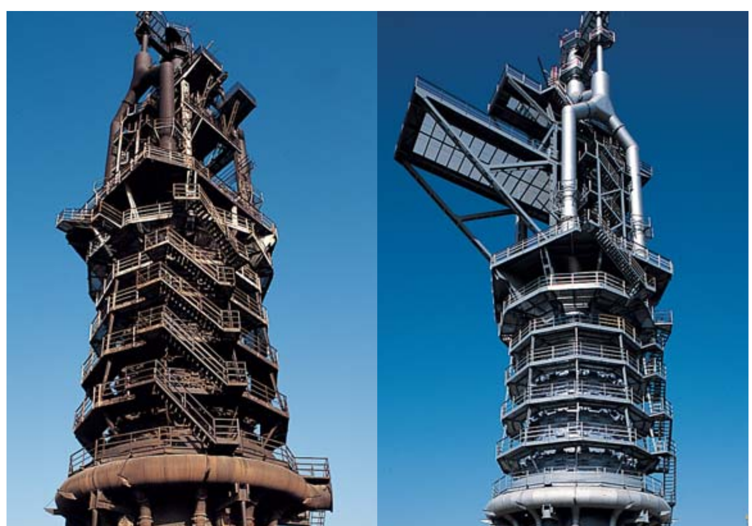
An acknowledged expert in the repair and strengthening of structures, Freyssinet has also made a name for itself in the restoration of historic monuments worldwide. This activity is one of the specialist skills developed by the Group's Spanish subsidiaries and is not limited to implementation operations alone. "The first step is to conduct an in-depth study of the structure, in particular in the case of very old buildings, using all the resources made available by science, technology and analysis," explains José María Roviralta, director of building rehabilitation for Freyssinet Spain. Before performing any operation, it is essential to have a perfect understanding of the geometry as well as of the building's spatial dimensions and volume, the materials of which it is composed and its behaviour. It is also necessary to take account of the traces left by history which make the monument what it is today: a living testament to the past. It is then necessary to identify the problems and the resulting site organization: the techniques to be used and the composition of appropriate teams.

Work cannot start until these detailed preparations have been completed. On site, the site manager must have a detailed roadmap including the schedule of works as well as management information. It is not always easy to predict the cost of this type of repair work accurately since the buildings can sometimes hold a few surprises during the operation. "When working on a historic monument, it is not uncommon to reveal remains which are identified by the archaeologists and fine arts experts we recruit to our teams," stresses J.M. Roviralta.

### A complicated, demanding profession

Three main activities are involved in historic monument operations: maintenance, restoration (indispensable and even obligatory) and rehabilitation (less frequent). The objective of maintenance is to limit the damage caused to the structure by external elements, whether natural or not. In this case, the structure is isolated from the effects of underground water (treatment of dampness), air (pollution) or sources of vibration. "Technological advances must contribute to our care of historic monuments by minimizing the production of pollution and providing increasingly efficient isolation techniques," says J.M. Roviralta, who adds that tourism also contributes to the degradation of historic buildings. Restoration, however, is governed by a key principle which consists of never adding something that was not there before. An incomplete or imperfect building must be left as it is. Errors of symmetry, for example, are an integral part of the structure and its history and often enable archaeologists to identify its date of construction or the architectural school to which it belongs. Modern technology can be used during building consolidation work. However, when strengthening work is required, repairs should be kept to a minimum in order to conserve the authenticity of the structures. As far as rehabilitation is concerned, this involves adapting the monument to modern life by adding new elements while respecting the original architecture.

In this field of activity where precise work is essential, there is, paradoxically, no specialist training for either operating personnel or engineers. Experience is acquired on site. Nevertheless, grants have recently been created by the various regions to allow personnel to benefit from ongoing training. Furthermore, the specialists who work on this type of building are not engineers but "technical architects" whose training and professional sensitivity are particularly suitable for this type of operation. ■



**One of the most publicized operations of this type to have been undertaken in recent years is the complete rehabilitation of the last blast furnace in Sagunto in the Valencia region. Reaching a height of 68m, this structure is listed as part of Spain's industrial heritage.**

# FROM FIREPROOF PRODUCTS TO FIRE SAFETY ENGINEERING

**Specialised in the design and manufacture of exclusive fire-proofing products for industrial applications, over the past 25 years Mecatiss has become the preferred fire safety partner for industry, bringing together 3 capabilities: engineering, product manufacture and implementation. Introduction to this subsidiary, which, after having been part of VINCI Energies for 5 years, joined the Freyssinet Group just a year ago.**

## Mecatiss

"The Mecatiss story really starts with the accident at the Three Mile Island nuclear power station in the USA on 28 March 1979, when three French engineers grasped the importance of proper protection for installations in sensitive environments," summarizes Bernard Marquez, the company's Managing Director. The idea took concrete form in 1980 in Morestel (Isère), where the company still has its headquarters today, with the establishment of MTS Mecatiss which marketed MPF2000, a cladding product consisting of a silicon-coated industrial fabric (which could therefore be decontaminated) surrounding a mineral wool and fire-retardant adhesive. This flexible, lightweight system, which can be adapted to any physical configuration and guarantees fire resistance for a period of four hours in industrial conditions where fire temperatures can reach 1300 C, was to revolutionize fire protection in industrial environments.

In France, which was resolutely forging ahead with the construction of nuclear reactors, this innovation met an essential need. Thus when EDF launched its national fire action plan in the early 1980s, it turned to Mecatiss to protect its cableways. However, even then, the company wanted to do more than simply protect cableways, and its engineers turned their attention to the overall protection of installations, in particular in the case of "wall passages" and the development of products designed to resist water, air and radiation.


1

### Certified products

From the very beginning, one of the company's most important characteristics was its ability to innovate (the company invests over 7% of its turnover in R&D) and secure the certification of its products. Nowadays, every product it invents undergoes a hundred or so internal tests, in particular in the company's furnace, in order to validate its effectiveness in all types of configuration. When the results are conclusive, these products are sent to external laboratories for further testing prior to approval. "This is a meticulous and rigorous task," explains Bernard Marquez, "because all the components have to be checked and the product cannot obtain overall certification until each individual element has been approved."

From the 1980s through to the years following 2000, the company has proven its expertise at all nuclear sites in France and has also been present at an international level: in Egypt, the USA, China, Russia, Bulgaria and the Ukraine. The company is growing, recruiting new staff, strengthening its production equipment and specializing in "fire sectorization", in other words, designing systems to contain a fire

**Joint effort and cooperation are a management principle at Mecatiss where employees have helped to come up with the company's new slogan: "fire protection, sealing: two challenges, one source of expertise".**

2

4

**1. A high value-added company, Mecatiss has its own production equipment which enables it to design, manufacture and test its products.**
**2. Injecting silicon foam.**
**3. Injecting a silicon elastomer for the protection of wall passages.**
**4. Given its role as a chemicals company, Mecatiss performs hundreds of tests every year to validate the formulation of its products in its integrated laboratory.**

3

in a defined space until it can be controlled and extinguished. Over time, these efforts have borne fruit and the company is now practically an essential partner for the nuclear and other industries, to the extent, says Bernard Marquez, “that in some industries, installation protection and maintenance managers talk about ‘mecatissing’ areas.”
At the same time, the company is increasingly establishing itself as a fully-fledged fire safety engineering enterprise which is capable of addressing and solving any problem in this sector in industrial environments and, in the near future, in the civil engineering field. After being bought by VINCI’s thermal-mechanical division in 1999 and becoming part of VINCI Energies in 2001, the company, which now has five R&D staff, four project engineers and a works manager in each of the six regions and 60 site workers, has been part of the Freyssinet Group since 2005: “There are many areas where we and Freyssinet complement each other,” says Bernard Marquez, “since alongside our long-standing expertise, we are increasingly moving into the field of fire protection in civil engineering structures and highway infrastructures, such as tunnels, for which we have perfected some high-performance products.” In this way, Mecatiss is consolidating its position as a fire safety engineer, recently validated by the renewal of its case 1 qualification (mécanique application tissus M / mechanical, applications, M fabrics) by EDF which has been extended to include assessments, engineering and consulting services. While the company's products and positioning clearly lie at the root of Mecatiss's success, this is also due to an original management approach involving all 80 of the company’s employees. By way of example, Bernard Marquez explains how “the company’s new slogan: 'fire protection, sealing: two challenges, one source of expertise' was proposed by Dominique Guipponi, a chemist, at the end of a joint action conducted in March. This slogan is now used alongside our logo.” ■

## PROFILE

- **Staff:** 5 R&D, 4 project engineers, 1 works manager per region, 60 site workers
- **R&D investment:** 7% of turnover.
- **Managing Director:** Bernard Marquez.

# EXPANSION JOINTS
# The art of making connections

**Assuring a smooth transition between abutments and structures and between structural elements, expansion joints represent a concentration of technology which is mostly neglected. The following is an overview of a construction element which represents one of Freyssinet's specialities.**

The industrial development of expansion joints, a relatively recent event in the history of civil engineering, primarily has its origins in the lengthening of the distances spanned by structures throughout the 20th century and in the increase in traffic volumes and loads. Since its first nosing expansion joints, Freyssinet has developed a whole range of sophisticated equipment to respond to all configurations.
Directly exposed to the strains of traffic and the weather, expansion joints must provide a smooth transition, while at the same time being durable and permitting the free distortion of the bearing surface in all three dimensions. These exacting demands have led many engineers to design a variety of solutions combining all available materials: metals; elastomers, concrete and hydraulic or synthetic mortars.
The innovatory path followed by this equipment is perfectly reflected by the main stages of development in the solutions offered by the Freyssinet Group. ■

1950/1960

## FT comb joints

Since simple nosing expansion joints were unable to cope with the longitudinal movements of the early large prestressed structures, which could reach several tens of centimetres, rigid combs coupled with a flexible elastomer, such as those already employed in bearing production, were used and gave rise to the first generation of FT joints (named after Fontenay-Trésigny, the town where the first model in this range was installed). Offering a whole new level of comfort, these joints can still be found in many structures and are used in a number of different countries.

**Thanks to the way in which they are formed, these comb joints create a genuine link between different structural sections.**

1970/1980

## The decade of optimization

To respond to growing economic demands, development focused on reducing production costs and rabbet-free installation. This led to the emergence of type M monoblock joints which could be manufactured considerably faster than FT joints or P joints (which are sunk into the surface) while still permitting the same level of movement. During this period, the company acquired its own production equipment and started manufacturing expansion joints, thus guaranteeing its customers excellent quality and adherence to deadlines.

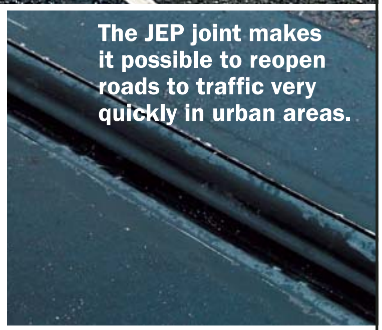
1990

# The range expands

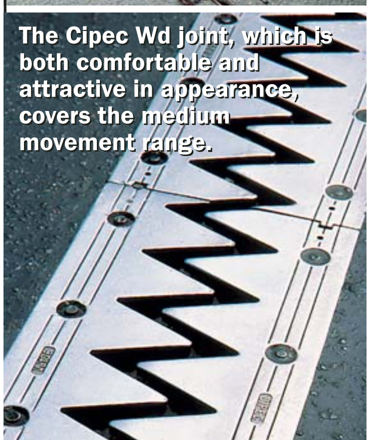
Since no universal joint existed, Freyssinet extended its range to meet the expectations of all its customers and respond to the demands imposed by a huge variety of traffic types and conditions, movement levels and environmental constraints.

Viajoint is an economical solution which offers exceptional user comfort for low levels of movement.

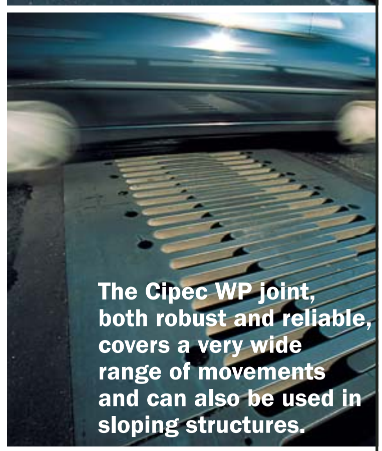
WR is the first joint with horizontal fixings for installation in the surfacing of the structure.



The JEP joint makes it possible to reopen roads to traffic very quickly in urban areas.



The Cipec Wd joint, which is both comfortable and attractive in appearance, covers the medium movement range.



The Cipec WP joint, both robust and reliable, covers a very wide range of movements and can also be used in sloping structures.

The Eole joint is used only for very large structures, in particular in earthquake zones. It permits a modular design while optimizing solutions for high levels of movement in all three dimensions. To test its products and validate their mechanical performance, the Group conducted large numbers of laboratory tests and, at the end of the 1990s, installed an endurance test bed specially designed to simulate heavy goods traffic.

2

3

1 and 2: P joint (nosing expansion joint).
3: M joint (monoblock)

2000

# Synthesis and sustainable development

Consideration of environmental factors, operating constraints and requirements concerning durability has made the continuous improvement of expansion joints a necessity. Freyssinet's range of solutions has recently been extended by a new product, the WM 80 joint, which pioneers a new range designed to combine the qualities of the W and M ranges. Designed on the basis of tested principles and making use of materials which are largely insensitive to traffic and pollution damage, these comfortable, silent and watertight monoblock components have been designed to withstand heavy traffic. Initial installations suggest a bright future.

# The Freyssinet Group around the world

## Africa and the Middle East

### Algeria
**Freyssinet International & Cie Algérie**
Algiers
Tel.: (213) 21 600 300
Fax: (213) 21 694 839

### Egypt
**Freyssinet Egypt**
Giza
Tel.: (20.2) 345 81 65
Fax: (20.2) 345 52 37

### Iran
**E-man Serve (Freyssinet Liaison Office)**
Tel.: (98) 21 8806 64 64
Fax: (98) 21 8806 64 20

### Kuwait
**Freyssinet International & Co.**
Safat
Tel.: (965) 906 7854
Fax: (965) 563 5384

### Morocco
**Freyssinet International & Cie Maroc**
Rabat
Tel.: (212) 37 56 44 35 / 37 71 73 68
Fax: (212) 37 71 39 48

### South Africa
**Freyssinet Posten Pty Ltd**
Olifantsfontein
Tel.: (27.11) 316 21 74
Fax: (27.11) 316 29 18

**Reinforced Earth Pty Ltd**
Johannesburg
Tel.: (27.11) 726 6180
Fax: (27.11) 726 5908

### United Arab Emirates
**Freyssinet Middle East LLC**
Dubai
Tel.: (971) 4 286 8007
Fax: (971) 4 286 8009

**Freyssinet Gulf LLC**
Dubai
Tel.: (971) 4 286 8007
Fax: (971) 4 286 8009

## The Americas

### Argentina
**Freyssinet**
Tierra Armada SA
Buenos Aires
Tel.: (54.11) 4372 7291
Fax: (54.11) 4372 5179

### Brazil
**Terra Armada Ltda**
Rio de Janeiro
Tel.: (55.21) 2233 7353
Fax: (55.21) 2263 4842

### Canada
**Reinforced Earth Company Ltd**
Mississauga
Tel.: (1.905) 564 0896
Fax: (1.905) 564 2609

### Chile
**Tierra Armada S.A.**
Santiago de Chile
Tel.: (56.2) 2047 543
Fax: (56.2) 225 1608

### Mexico
**Freyssinet de México – Tierra Armada S.A.**
Mexico DF
Tel.: (52.55) 5250 7000
Fax: (52.55) 5255 0165

### United States
**Drainage & Ground Improvement, Inc - Ménard**
Bridgeville, PA
Tel.: (1.412) 257 2750
Fax: (1.412) 257 8455

**Freyssinet LLC**
Sterling, VA
Tel.: (1.703) 378 2500
Fax: (1.703) 378 2700

**The Reinforced Earth Company**
Vienna, VA
Tel.: (1.703) 821 1175
Fax: (1.703) 821 1815

### Venezuela
**Tierra Armada Ca**
Caracas DF
Tel.: (58.212) 576 6685
Fax: (58.212) 577 7570

## Asia

### Hong Kong
**Freyssinet Hong Kong Ltd**
Kwung Tong - Kowloon
Tel.: (852) 2794 0322
Fax: (852) 2338 3264

**Reinforced Earth Pacific Ltd**
Kwung Tong
Tel.: (852) 2782 3163
Fax: (852) 2332 5521

### Indonesia
**PT Freyssinet Total Technology**
Jakarta
Tel.: (62.21) 830 0222
Fax: (62.21) 830 9841

### Japan
**FKK**
Tokyo
Tel.: (81.3) 5220 2181
Fax: (81.3) 5220 9726

**TAKK**
Tokyo
Tel.: (81.44) 722 6361
Fax: (81.44) 722 3133

### Malaysia
**Freyssinet PSC (M) Sdn Bhd**
Kuala Lumpur
Tel.: (60.3) 7982 85 99
Fax: (60.3) 7981 55 30

**Ménard Geosystems Sdn Bhd**
Subang Jaya Selangor
Tel.: (60.3) 5632 1581
Fax: (60.3) 5632 1582

**Reinforced Earth Management**
Services Sdn Bhd
Kuala Lumpur
Tel.: (60.3) 6274 6162
Fax: (60.3) 6274 7212

### Pakistan
**Reinforced Earth**
Pvt Ltd
Islamabad
Tel.: (92.51) 2273 501
Fax: (92.51) 2273 503

### Singapore
**PSC Freyssinet (S) Pte Ltd**
Singapore
Tel.: (65) 6899 0323
Fax: (65) 6899 0761

**Reinforced Earth**
(SEA) Pte Ltd
Singapore
Tel.: (65) 6316 6401
Fax: (65) 6316 6402

### South Korea
**Freyssinet Korea Co. Ltd**
Seoul
Tel.: (82.2) 2056 0500
Fax: (82.2) 515 4185

**Sangjee Ménard Co. Ltd**
Anyang-Si – Kyunggi-Do
Tel.: (82.2) 587 9286
Fax: (82.2) 587 9285

### Thailand
**Freyssinet Thailand Ltd**
Bangkok
Tel.: (66.2) 266 6088/90
Fax: (66.2) 266 6091

### Vietnam
**Freyssinet Vietnam**
Hanoi
Tel.: (84.4) 826 1416
Fax: (84.4) 826 1118

## Europe

### Belgium
**Freyssinet Belgium NV**
Vilvoorde
Tel.: (32.2) 252 0740
Fax: (32.2) 252 2443

**Terre Armée Belgium NV**
Vilvoorde
Tel.: (32.2) 252 0740
Fax: (32.2) 252 2443

### Denmark
**A/S Skandinavisk**
Spaendbeton
Vaerlose
Tel.: (45.44) 35 08 11
Fax: (45.44) 35 08 10

### France
**Freyssinet France**
Vélizy
Tel.: (33.1) 46 01 84 84
Fax: (33.1) 46 01 85 85

**Freyssinet International & Cie**
Vélizy
Tel.: (33.1) 46 01 84 84
Fax: (33.1) 46 01 85 85

**Ménard Soltraitement**
Nozay
Tel.: (33.1) 69 01 37 38
Fax: (33.1) 69 01 75 05

**PPC**
Saint-Eusebe
Tel.: (33.3) 85 73 69 06
Fax: (33.3) 85 73 69 13

**Terre Armée SNC**
Vélizy
Tel.: (33.1) 46 01 84 84
Fax: (33.1) 46 01 86 87

### Fyrom
**Freyssinet Balkans**
Skopje
Tel.: (389.02) 3118 549
Fax: (389.02) 3118 549

### Germany
**BVT Dyniv GmbH**
Seevetal
Tel.: (49) 4105 66 480
Fax: (49) 4030 23 98 25

**Bewehrte Erde**
Seevetal
Tel.: (49) 4105 66 48 16
Fax: (49) 4105 66 48 66

### Great Britain
**Corrosion Control**
Services Ltd
Telford
Tel.: (44.1952) 230 900
Fax: (44.1952) 230 906

**Freyssinet Ltd**
Telford
Tel.: (44.1952) 201 901
Fax: (44.1952) 201 753

**Reinforced Earth Company Ltd**
Telford
Tel.: (44.1952) 201 901
Fax: (44.1952) 201 753

### Hungary
**Pannon Freyssinet Kft**
Budapest
Tel.: (36.1) 209 1510
Fax: (36.1) 209 1510

### Ireland
**Freyssinet Ireland**
Kildare
Tel.: (353) 45 884 896
Fax: (353) 45 884 969

**Reinforced Earth Company Ireland (Ltd)**
Kildare
Tel.: (353) 45 431 088
Fax: (353) 45 433 145

### Italy
**Terra Armata S.r.l**
Rome
Tel.: (39.06) 45 49 51 00
Fax: (39.06) 45 49 51 01

### Netherlands
**Freyssinet Nederland BV**
Waddinxveen
Tel.: (31.18) 2630 888
Fax: (31.18) 2630 152

**Terre Armée BV**
Waddinxveen
Tel.: (31.18) 262 27 35
Fax: (31.18) 263 60 31

### Norway
**A/S Skandinavisk**
Spennbetong
Snarøya
Tel./fax: (47.67) 53 91 74

### Poland
**Freyssinet Polska Sp z.o.o.**
Milanówek
Tel.: (48.22) 792 13 86 / 724 68 93
Fax: (48.22) 724 68 94

### Portugal
**Freyssinet - Terra Armada**
Lisbon
Tel.: (351.21) 716 1675
Fax: (351.21) 716 4051

### Romania
**Freyrom SA**
Bucharest
Tel.: (40.21) 220 2828
Fax: (40.21) 220 4541

### Russia
**Freyssinet**
Moscow
Tel.: (7 495) 747 51 79
Fax: (7 495) 747 51 79

### Slovenia
**Freyssinet Adria**
Ajdovscina
Tel.: (386) 5 36 90 331
Fax: (386) 5 36 90 200

### Spain
**Freyssinet SA**
Madrid
Tel.: (34.91) 323 9500
Fax: (34.91) 323 9551

**Ménard Soltraitement**
Madrid
Tel.: (34.91) 323 9550
Fax: (34.91) 323 9551

**Tierra Armada SA**
Madrid
Tel.: (34.91) 323 9500
Fax: (34.91) 323 9551

### Sweden
AB Skandinavisk
Spaennbetong
Malmö
Tel./fax: (46.40) 98 14 00

### Switzerland
**Hebetec Engineering AG**
Hindelbank
Tel.: (4134) 411 71 71
Fax: (4134) 411 71 70

**Freyssinet SA**
Moudon
Tel.: (4121) 905 09 05
Fax: (4121) 905 09 09

### Turkey
**Freysas**
Kadiköy – Istanbul
Tel.: (90.216) 349 8775
Fax: (90.216) 349 6375

**Reinforced Earth Insaat**
Proje Ve Tic. A.S
Umraniye – Istanbul
Tel.: (90.216) 484 4179
Fax: (90.216) 484 4174

## Oceania

### Australia
**Austress Freyssinet Pty Ltd**
North Ryde, NSW
Tel.: (61.2) 9491 7177
Fax: (61.2) 9491 7199

**Austress Menard**
North Ryde, NSW
Tel.: (61.2) 9491 7100
Fax: (61.2) 9491 7111

**Austress Freyssinet Pty Ltd**
North Melbourne, VIC
Tel.: (61.3) 9326 58 85
Fax: (61.3) 9326 89 96

**The Reinforced Earth**
Company
Hornsby, NSW
Tel.: (61.2) 9910 9910
Fax: (61.2) 9910 9999

### New Zealand
**Freyssinet New Zealand Ltd**
Reinforced Earth Ltd
Auckland
Tel.: (64.9) 2363 385
Fax: (64.9) 2363 385


**FREYSSINET**

1 bis, rue du Petit-Clamart - 78140 Vélizy-Villacoublay - Tel.: 01 46 01 84 84 - Fax: 01 46 01 85 85 - www.freyssinet.com Editorial Manager: Claude Lascols - **Editor:** Stéphane Tourneur (communication@freyssinet.com) **The following people contributed to this magazine:** Cécile Baubeau, Stéphane Cognon, Etienne Dhiver, Guy Gonidec, Gary Hall, Geoffrey Holdings, Dominique Jullienne, Marc Lacazedieu, Benoît Lecinq, Philippe Liausu, Bernard Marquez, Habib Merabet, Pierre Mellier, Patrick Nagle, Jose María Noval, Karol Paltsios, Pedro Pinto, Dimitri Plantier, Cyril Plomteux, Ines Rebelo Pinto, José María Roviralta, Pierre Sery, Larry Sessions, Jérôme Stubler, Serge Varaksin - **Editorial Secretary:** Jean-Marc Brujaille -Design and creation: Idé - **Cover photo:** soil strengthening work in Hamburg, Axel Heise. - Photo credits: Yves Boucaux, Axel Heise, Francis Vigouroux, S&T, Freyssinet picture archive. ISSN: No. 1763-0142