

# Soils & Structures

THE FREYSSINET GROUP MAGAZINE

**REALIZATIONS** 2,700,000 M<sup>2</sup> OF SOIL CONSOLIDATION IN EIGHT MONTHS

**COMPANY** REINFORCED EARTH COMPANY IRELAND AND FREYSSINET IRELAND

**HISTORY** MENARD VACUUM: THE FORCE OF THE VACUUM

N° 226 Second half 2007

SLIDING AND MOVING  
STRUCTURES  
**BOISSY-SAINT-LÉGER**  
A RECORD PROJECT  
FOR A TECHNIQUE  
IN MOTION



Sustainable technology

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## 2007 VINCI INNOVATION AWARDS

# Freyssinet is awarded the Grand Prize

Among the prizewinners of the 2007 VINCI Innovation Awards publicised on 4th December 2007 in Paris, Freyssinet was awarded the Grand Prize for its tubular structure strengthening system using carbon fiber rods and cement grout, a project submitted by a Freyssinet France team headed up by Marc Jeulin. This award adds to the three prizes awarded to the Group by the competition's regional panels last September and October. The Île-de-France region awarded the Materials Prize to Freyssinet France for its Kevlar matting fabric (a Kevlar matrix protecting concrete supports from strong impacts and preventing their deterioration).

The International and Centralized Activities region awarded the panel's Special Prize to Reinforced Earth Pty Ltd for its TerraNail solution for walls (anchored composite earth is used to construct a very high Reinforced Earth structure on an existing slope, leaving a space of only 2 m at the base). Finally, the Rhône-Alpes region awarded the Safety Prize to Freyssinet France for its "foot protector" (to prevent pneumatic pick accidents, Freyssinet Rhône-Alpes has designed a protective shell to eliminate the risk of foot injury.) Soils & Structures will look at these projects more extensively in a later issue and would like to congratulate all the prize winners.



# THE FREYSSINET INNOVATION WINS THE AWARD AGAIN



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**O**n 4 December 2007, Freyssinet was awarded the Grand Prize at the 2007 VINCI Innovation Awards. Following the 2001 and 2005 awards, this is a new accolade for the creative, inquisitive and inventive spirit that has dominated the Group since its beginnings. A fitting homage to Henri Vidal, the inventor of Reinforced Earth, who left us last autumn. Congratulations to the

Grand Prize winning teams and the other award-winners. Thanks to everyone who took part in the competition. The 2007 Grand Prize was awarded to the tubular structure strengthening system using carbon fiber rods and cement grout. A simple, elegant, effective and economic solution for pylons carrying mobile telephone network antennas. A solution that subscribes perfectly to the Group's new motto "Sustainable Technology", thanks to the savings in steel it represents. "Sustainable Technology" is a relevant motto, as we will from now on be drawing up our solutions using PIC software, which will establish the environmental impact of our techniques. Freyssinet, Reinforced Earth and Ménard, more than ever before, are working within a context of dynamic growth, innovation and respect, even anticipation, of the constraints of sustainable development. ■

**Bruno Dupety**  
Chairman of Freyssinet

1. Xavier Huillard awards the Grand Prize to Christian Tourneur, José Alvarez and Marc Jeulin.
2. Incorporated on the vertical posts of the pylons, the Grand Prize winning reinforcement system means the pylons can carry a large number of GSM network antennas.
3. The cement grout is injected into the tube at the base.
4. A clamp keeps the carbon fiber rods parallel and centered in the tube.
5. Candido Taveira and Bertrand Petit (Safety Prize).
6. . Louwtjie Maritz, Taffy Vadron and Andrew Smith (panel's Special Prize).
7. Jean-Marc Vilpellet (Materials Prize).



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## Success with a Reinforced Earth alternative

**France.** The Saint-Julien en Genevois-Villy le Pelloux (Haute-Savoie) section is the last link of the A41 motorway and a 19 km key route that will link the principal cities of the alpine valley: Grenoble, Chambéry, Annecy and Geneva. Terre Armée SNC was involved in the construction of this section up to the La Ravoire underpass (n° 161). In partnership with the A41 EIG, the company proposed Reinforced Earth abutments, combined with two isostatic decks with a 35 m span, as an alternative to a multi-span viaduct. Terre Armée SNC designed the two, exceptionally high 22 m abutments, covering a facing area of nearly 4,000 m<sup>2</sup>, and supplied the TerraClass panels and reinforcements. On site, in addition to checking the general stability of the walls in relation to the geotechnical conditions of the in situ soil, the company provided technical assistance with the assembly work and quality control checked the fabrication of the reinforcements and facings. As part of this contract, Terre Armée was also involved in constructing the Troinex TerraClass wall under the roadway and the Noiret cut-and-cover tunnel head TerraTrel mineral walls.

## A “design & build” contract for Reinforced Earth

**United States.** Reinforced Earth (RECo) has secured a contract to supply over 51,000 m<sup>2</sup> of Reinforced Earth walls for the largest road widening scheme in Missouri’s history. The design & build contract, the first of its kind for the State, involves rebuilding and modernizing a 16 km stretch of Interstate Highway 64 and its interchanges close to the St. Louis city center. Given this kind of contract, RECo will be carrying out design work on fabrication and construction over 18

months, while the facings will be prefabricated over a period approaching 27 months. The work will take a total of 4 years. RECo will supply some 12,000 individual 1.5 x 3 m facing panels as well as over 2,500 prefabricated elements required to create more than 76,000 m of slab. The engineering and the execution of the work is supervised by the RECo office in Dallas (Texas). The elements required to build the first wall were delivered at the beginning of November.

# 1,200 tonnes of steel for LNG storage tanks

**Spain.** The Mugarodos natural gas storage facility, built by Acciona and located in the region of La Coruña (Galicia), will ultimately supply two power stations currently under construction: the Endesa plant at As Pontes and the Fenosa plant at Sabón. Freyssinet has just finished installing the prestressing of the site’s two LNG storage tanks, each with a capacity of 150,000 m<sup>3</sup>. 1,200 tonnes of steel were used.

## Prestressed floors for social housing



**Singapore.** In Tampines, on the west of the island, Freyssinet is involved in a novel social housing construction project, marking the launch of the Singaporean Ministry of National Development’s Design, Build & Sell Scheme (DBSS). The

architecture of the Tampines pilot complex, which consists of eight 17-storey buildings and two multilevel car parks, will respect the principal high-rise building standards and use innovative solutions. The client opted for the 200 mm thick prestressed floors proposed by the Group’s Singaporean subsidiary for the residential buildings. Therefore, the Freyssinet PSC teams worked in close conjunction with the builder throughout the commercial proposal and design phases, to meet the specific requirements of structures with such modern architecture.

## Support for the motorway



**Malaysia.** As a preliminary stage to constructing the east coast motorway linking the cities of Kuantan (in the South) and Kuala Trengganu (in the North), Menard Geosystems carried out soil improvement work over a 130,000 m<sup>2</sup> area. Two techniques were used: dynamic compacting and vertical drains

(representing a total of 500,000 linear metres).



## Prestressing on the Tagus

**Portugal.** The Carregado bridge, which crosses the Tagus in the Santarém region, approximately sixty kilometres upstream of Lisbon, is one of the largest engineering structures built in Portugal (11,570 m). Between January and June 2007, Freyssinet-Terra Armada was involved in the installation of the internal and external prestressing of the viaducts built by successive cantilevering. Working together with the Freyssinet S.A. Technical Department in Madrid, Freyssinet-TA also carried out the horizontal loading of the spans in order to anticipate delayed-action losses.

## Prestressed floors for a skyscraper

**Spain.** Freyssinet carried out the prestressing of the foundation slab and floors of the Torre Espacio in Madrid, one of four skyscrapers making up a new 200 m high office complex built on the site of the former Real Madrid sports facility in the north of the city.



## Obituary



**Mexico.** Enrique Sanroman, Managing Director of Freyssinet de México and Tierra Armada SA de CV, died in Mexico on 10 September 2007 at the age of 53. Engineer, he joined Freyssinet de

México in 1981 after starting his career at Euro Estudios, design consultants. Successively "Superintendente" then western area manager, he became the head of the Group's Mexican subsidiary in 1998 as Managing Director of Freyssinet de México and Tierra Armada S.A de C.V. He notably developed the Reinforced Earth business (retaining walls and TechSpan arches) in Mexico, while at the same time strengthening the subsidiary's Structures business in the field of prestressed floors, civil engineering structures and repairs. On behalf of the Freyssinet Group, we would like to extend our sincere condolences to his family and friends.

## A prestressed shopping centre

**Romania.** In Bucharest, the designers of the new shopping centre in the Berceni district, for which work began in November 2007, chose the prestressed concrete floor solution proposed by Freyrom to cover an area of 35,000 m<sup>2</sup>. After conducting the studies, the subsidiary is supplying and will install 380 tonnes of sheathed greased strands and 12,000 flat anchors between now and March 2008.



## Precast silos

**United States.** Early in September in Fort Smith (Arkansas), the Reinforced Earth subsidiary finished building 15 storage silos for the US army. Consisting of TechSpan arches, these round structures, which would be worthy of the name igloos across the Atlantic, were filled and faced with continuous spandrel walls composed of TerraClass panels. "Using precast arches was an efficient and cost-effective alternative to the original solution, which was to build these structures using concrete cast in situ," explains John Shall, Business Development Manager of Reinforced Earth.



## CMC in New York

**United States.** In the Big Apple's Brooklyn district (New York), DGI Menard installed more than 200 controlled modulus columns (CMC) to strengthen the foundations of a new building. In a very small area dense with infrastructure and construction (buildings, tunnels etc.), the execution of the work proved to be a very delicate operation.

## A Reinforced Earth noise-prevention wall

**Germany.** The town of Haan-Gruiten, 20 km from Dusseldorf, chose the solution proposed by Bewehrte Erde, the Group's German subsidiary, for a noise-absorbing wall destined for a new ring road. "The Reinforced Earth wall is made of a porous concrete that can absorb 8 dB, which is considered "highly absorbent" by the German Railway Association," points out Marko Bruggemann, managing director of the subsidiary. This Reinforced Earth solution was chosen as an alternative to precast concrete walls because rail traffic would not be interrupted.



## 6,000 CMC for a car park

**France.** The Ménard teams installed 6,000 controlled modulus columns (CMC) as part of the Deux Lions car park construction project in Tours (Indre-et-Loire).



## Prestressing for a helistop

**France.** The CHU, University Hospital Center of Toulouse (Haute-Garonne), the fourth largest in France, has embarked upon a major program to modernize and rebuild its infrastructures for the next ten years. For regulatory reasons, its helistop had to be moved from the south to the north of the site. Freyssinet carried out the post-tensioning of a 2,200 m<sup>2</sup> reinforced concrete slab designed to receive three helicopters. A total of 240 1F15 cables with sheathed greased strands have been installed.



## An award for a soil-bentonite wall

**Australia.** Australian Engineers has just awarded the Environmental Engineering Excellence Award 2007 to the waterproof soil-bentonite barrier constructed in 2006 in New South Wales to prevent the contaminated land of the former Newcastle steelworks from polluting the Hunter river. Developed by Ménard's Australian subsidiary (Freyssinet), this containment solution, which is quick to install, proven and attractively priced, was preferred to competitors' solutions of cement grout or deep soil mixing walls (see S&S n° 224, p. 30). This award recognizes the excellence of an innovative technique that contributes to environmental protection. It was presented jointly by several partners: Regional Land Management Corporation, Austress Menard, URS Australia and Douglas Partners.

## Reinforced earth in Colorado Springs

**United States.** Colorado Springs recently launched a project to expand its main urban highway over a 19 km section. The subsidiary of the Reinforced Earth Group is involved in the work, designing and supplying the materials for various Reinforced Earth walls totaling 29,600 m<sup>2</sup> of retaining walls with different facings (TerraPlus, TerraTrel).

## Stay cables and prestressing on the Ohio



**United States.** On the borders of West Virginia and Ohio, Freyssinet has completed the installation of the stay cables on the Blennerhasset Island Bridge, an arch bridge crossing the Ohio very near Parkersburg. The structure consists of a prestressed mixed deck suspended by two planes of

26 stay cables. Its main arch is 265 m long. The installation of the stay cables (27T15 type cables) took place in difficult conditions as the teams had to carry out the anchorage work in confined spaces that were hard to access. Work on the barge from which the strands and sheaths were hoisted also had to accommodate the river traffic. In addition to supplying and installing the stay cables, Freyssinet was also asked to supply and provide technical support for the installation of the structural prestressing, the pier headers and the deck slab.

## 125,000 m<sup>2</sup> of dynamic compaction

**Spain.** In Saragossa, the capital of Aragon, which will play host to the 2008 World Exhibition, Ménard began the soil improvement work of a 125,000 m<sup>2</sup> logistics platform last September. The work involved the use of the high-energy dynamic compaction technique.

## Obituary



It was with great sadness that we learnt of the death of **Michel Jarry**, at the age of 58, on 10 December 2007. Michel Jarry, Administrative and Accounting Director in the Freyssinet Structures Division, passed away as peacefully as possible. We will remember a companionable and courteous gentleman, who was a complete professional, working tirelessly on the Group's behalf. At this sad time, our thoughts go out to his family and those who met with him in their daily work and had learned to appreciate his profound human virtues.



Mr. **Henri Vidal** died on 29 November 2007. A former student of the Ecole Polytechnique, Roads and Bridges Civil Engineer and state-registered DPLG architect, Henri Vidal was responsible for one of the greatest innovations in recent civil engineering: Reinforced Earth retaining walls combining backfill and reinforcements to create an innovative composite material. He filed the first patents for his invention in 1963 and was very quickly responsible for the creation of major structures in several countries for extremely varied applications (road, rail, sea and river, industrial and military protection). The growth of the activity was accompanied by the opening of subsidiaries (in France in 1968, United States in 1971, Spain in 1972) and the distribution of licenses in Japan in 1974. It was not long before Terre Armée became the world benchmark in the field of reinforced earth, and 1979 saw the publication of a set of recommendations and professional standards for Reinforced Earth structures. Over time, Henri Vidal developed his invention and gradually launched plantable structures, walls with wire facing, precast arches etc. Henri Vidal retired from the business in 1998 when Terre Armée Internationale joined the Freyssinet group.

We would like to extend our sincere condolences to Michel Jarry and Henri Vidal families and friends.

## Work is completed

**United Arab Emirates.** In Abu Dhabi, Ménard completed three soil improvement projects in the last quarter of 2007. One was part of the expansion of a gypsum plant and the two others were a preliminary stage to building the Gulf Hotel complex and logistics centre (see photo above).





# Boatmen on the Volga

A new piers bridge is under construction over the great Russian river near Oulianovsk. The 4,200 tonnes, 60 m long steel spans, which were delivered by barge, were hoisted to a height of 45 m over the piers using 16 jacks with a 4,000 kN capacity supplied by Hebetec (see also page 31).



# Winning back the desert

In Saudi Arabia, 80 km north of Jeddah, Ménard has begun soil consolidation work on a 2,700,000 m<sup>2</sup> platform on which the King Abdullah Science and Technology University is to be built by 2009 (see also page 18).





# BOISSY-SAINT-LÉGER A RECORD PROJECT FOR A TECHNIQUE IN MOTION

**Last August, the operation to slide a rail bridge weighing more than the Eiffel Tower, a world first in the Paris region, placed one of Freyssinet's key areas of expertise in the spotlight: moving the structure using jacking and a wide range of techniques.**

A stone's throw from the Boissy-Saint-Léger (Val-de-Marne) RER station, the successful installation of two rail bridges, one using the Autofonçage technique and the other the Autoripage technique, was, on Sunday 5 August, a ceremonial occasion for Jean-Marie Beauthier, the inventor of the processes and founder of JMB Méthodes, acquired by Freyssinet in 2005. The use of two techniques for two structures situated only a few metres apart in the same time slot, during which traffic was stopped, was in fact a world first. Yet also unprecedented for this project were the extraordinary dimensions of the structures, one weighing 3,500 tonnes and the other 12,500 tonnes, compared with the 2,000 to 2,500 tonnes normally moved. "This operation was therefore a record-breaker and the high point of my career," acknowledges Jean-Marie Beauthier, "nevertheless, it was a feat, as weight is not a limit to the use of the method." The engineer continues, "The raft incorporated into the structures limits the pressure to 0.5 to 0.7 bar per square cen-

timetre. That's less than the pressure exerted by the soles of our shoes, which almost all soils can take without any preparation."

#### Mix of methods

For the Freyssinet SCCM (Centralized Cables and Handling Department) teams, who specialize in preparing and performing this type of operation under the direction of Jean-Luc Bringer, it all started in mid-July with the delivery of the two structures by the Guintoli-Eiffage consortium, which had been awarded the civil engineering contract. 36.64 m from its final position, PS8 (3,500 tonnes) was to be used for a local road and included a cycle path. For connoisseurs, the square profile of the frame was the clue that it would be put into place using the Autofonçage sinking technique. However, Jean-Marie Beauthier was planning to use a novel mix of his methods this time, as the whole of PS8 was to be positioned by launching from one side only and not by bringing together two half-frames built on either side of the embankment, as would be the case if the method was strictly applied. ▶▶

**Under the raft of the 12,500 tonne structure, the pressure on the soil was no more than the pressure exerted by the sole of a shoe.**





1



2

The first phase of the operation was to dismantle the existing tracks and dig out the SNCF (French railways) embankment (1) where the new rail bridge (2) was to be situated. In order to facilitate the sliding, pressurised bentonite was injected under the structure's raft (3). All the operation data were centralised, in real-time, at the control centre (4) in order to control the jack movements (5).



3



4



5

►► Several metres from PS8, further away from its final position (43.20 m) due to its height, equivalent to a five-storey building (10 m), was PS7, which was to take the four-lane N19 expressway, an impressive 60 m long structure with three piers and two struts, patented devices designed to limit the earthworks required and above all to eliminate the need for tedious, time-consuming technical backfilling work. Less noticeable at first glance were the two guide rafts underneath each structure, which would act as a bearing for positioning. Day by day, the preparatory work progressed. The cables were anchored in the housings provided

in the guide rafts and connected to the jacks that would be used to launch the structures. Then it was the turn of the bentonite injection equipment (the bentonite would act as a lubricant between the footings of the structures and their guide rafts, then the ground), the high capacity hydraulic pumps that would ensure the rapid operation of the jacks (movement can be at a rate of up to 12 m/hr), the electrical equipment and safety devices, the measuring instruments (laser telemetry sights) provided by Advitam and finally the jack control centre, which gathers all of the data about the maneuver and is used to check that the forces applied remain ►►

## As high as a five-storey building, PS7 must cover 43.20 m to reach its final destination.



1



2



3

**1.** A screen at the control center displays all the movement measurements recorded by the Advitam laser telemetry sight systems.  
**2.** Since the first project in 1984, Jean-Marie Beauthier (on the right), pictured here alongside Philippe Zanker, Director of Freyssinet France, has been on site for all the Autofonçage and Autoripage operations.  
**3.** Overview of the site on 5 August: PS8 (left) is in place, PS7 (right) has only a few metres to go.

## A NEW STATION TERMINUS

Jacks, which are used in Autoripage and Autofonçage, are key tools in lifting and can produce impressive moving operations. Bearing witness to this, is the operation undertaken last summer in Houten (The Netherlands), several kilometres south of Utrecht, where the former station (1), built in 1868 and since then becoming a school, residential housing and finally an office building, was moved in one piece over 150 m in order to increase the number of tracks. “We were awarded the design & build contract,” explains Caspar Lugtmeier, Technical and Commercial Manager of Freyssinet Nederland BV, “and as main contractor, we defined the methods, including the movement method, and all other aspects of the project.” The first stage was to create under the building, built at an underground level, a reinforced concrete frame (also part of the definitive foundations), consisting notably of seven large and multiple smaller beams (2) and to install, using vibration-free drilling, the temporary foundations destined to support the lifting frameworks. Jutting out on either side of the building, each of the seven beams then received its lifting system, a steel lifting framework supporting a jack, taking up the load of the structure and the reinforced concrete frame (approx. 825 tonnes) by means of 14 prestressing bars (3), each bar backed up by two smaller ones. After the building was lifted to a height of roughly 3 m, an operation undertaken on 10 August using the LAO (computer-aided lifting) system, and the steel plates of the transportation path had been put in position, the former station was placed on two trailers with a total of 192-wheels (4) and moved to its new location 150 metres away (5-6) in just 2 hours on 24 August. Supported by its lifting system for the time needed to release the trailers (7), the station could then finally be positioned on its new foundations in the days following the transport (42 concrete piles, 21 foundation blocks).

**PARTICIPANTS** • **Owner:** Gemeente Houten (municipality of Houten); Bataafse Alliantie (consortium) • **Main contractor:** Freyssinet Nederland BV • **Sub-contractors:** Goorbergh Funderingstechnieken (foundations); Sarens Nederland BV (trailer); Konstructieburo Snetselaar (detail engineering).



1



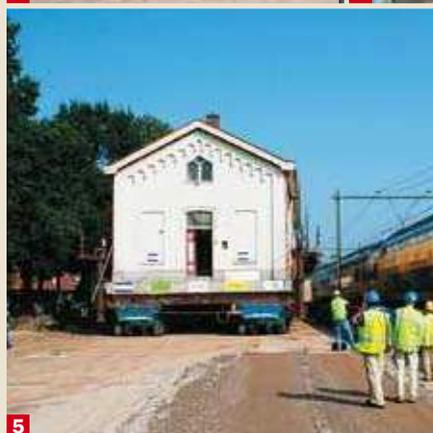
2



3



4



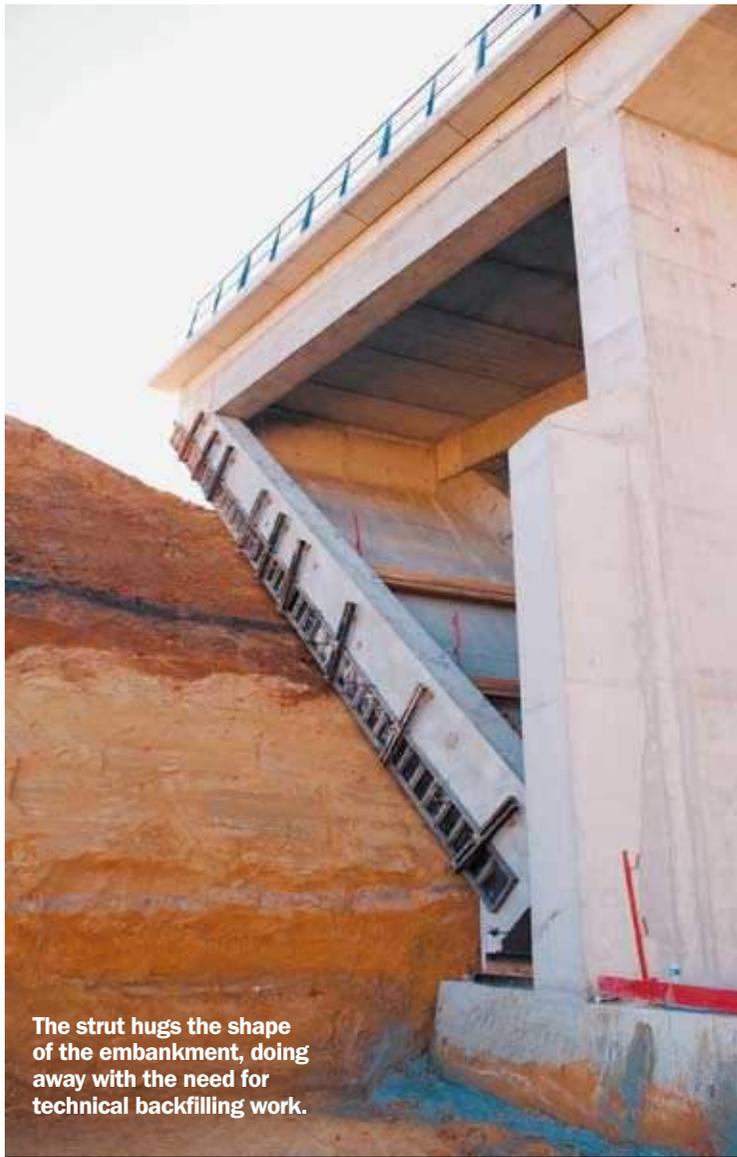
5



6



7



The strut hugs the shape of the embankment, doing away with the need for technical backfilling work.

►► within the permissible range and that the movement and trajectory are in line with predictions. “On Friday 3 August, just before the slot scheduled for the operation the next day, we proceeded with the “pre-sliding”, a dress-rehearsal of the operation limited to a movement of 50 cm to check everything was ready,” says Jean-Luc Bringer. On D-Day – Saturday 4 August – after disabling the catenaries (switching off the electricity supply), opera-

tions commenced. They would continue until service resumed on the tracks. At 19:00 hours the bentonite injections commenced in preparation for the first movements of PS8, escorted by the earthworks contractors with their diggers fitted with dredging shovels clearing the final centimetres of earth to leave a completely flat, level path in front of the sliding surface. For their part, the SNCF teams sectioned and removed the rails and then cleared the bal-

## A 50 cm dress-rehearsal to check everything was ready.



### Autofonçage, Autoripage

#### FIRST AND FOREMOST REDUCING THE IMPACT OF WORK ON TRAFFIC

Developed by Jean-Marie Beauthier in the 1980s and patented in 1984, the Autofonçage® sinking method aims to reduce as far as possible the impact of positioning an underground structure beneath a railway, road or motorway. Built on either side of the tracks, in optimum safety conditions for the workers, the two components that form the structure are connected and positioned underground, without requiring the dismantling of the track, using a cable and jack system. Implemented for the first time in 1984 at Champigny-sur-Marne to cross the tracks of the outer circle line under 4 m of earth, in the same year the process was awarded the Prize for Innovation, presented to Jean-Marie Beauthier by Jean-Louis Giral, President of the FNTP (National Federation of Public Works), and Paul Quilès, the then Minister for Transport. It was then used five times on the North TGV line. In the 1990s, Jean-Marie Beauthier started work on developing a new method, Autoripage, to overcome the guidance difficulties encountered with Autofonçage for

skewed structures. Placed on a “guide raft”, the structure is positioned after dismantling the tracks and digging out the SNCF embankment. Since its first application at Sucy-en-Brie for RATP in 1992, the system has seen a number of patented improvements. “The slid structures were initially straight, and technical backfilling had to be carried out on each side of the bridge, which was tedious and didn’t prevent the risk of compaction under the tracks,” explains Jean-Marie Beauthier. “I therefore had the idea of turning the breast wall into a strut, which gives the structures a new geometry that hugs the sloped shape of the opening and allows for narrower structures to be designed.” Other patented ‘tricks’ are characteristic of the method, such as the cable anchoring system on the guide raft and the standardized stroke of the jacks, which allows for an accurate 1 m forward movement every three maneuvers. Some 130 structures have been installed using Autofonçage or Autoripage since 1984.

last on the portion of track intended for PS7, before making way for the Guintoli diggers, which were to move the 35,000 m<sup>3</sup> of soil from the opening.

### 9,000 tonne launching capacity

When the upper launching nose of PS8 came into contact with the embankment, this marked the start of the second phase of Autofonçage, with the diggers going to work to clear the material as if from the working face of a mine until the structure reached its final position at 06:00 hours on the Sunday morning. Just a little time needed for the Freyssinet engineers to transfer various pieces of equipment and, at 13:00 hours, the PS7 Autoripage operation was launched. "We had fitted PS7 with three 1,000-tonne jacks on the outer piers and six 500-tonne jacks at the central pier. We therefore had a launching capacity of 9,000 tonnes, only two-thirds of which was used," points out Jean-Luc Bringer. "In total, the operation lasted 17 hours and was completed at 06:00 hours on the Monday." With the structures in place, the Freyssinet teams simply had to replace the bentonite grout underneath the raft with cement grout and the Guintoli/Eiffage teams had to fill the gap between the embankment and the strut with mortar, whilst SNCF replaced the tracks on the upper level. The next day, as soon as it was loaded onto the lorries, the Freyssinet equipment headed south for a new operation scheduled for 12 August in Perpignan. ■

### PARTICIPANTS

- ▶ **Owner:** Dirif 94
- ▶ **Delegated owner:** RATP
- ▶ **Consultant:** Xelis (RATP)
- ▶ **Main contractor:** NGE Génie Civil - Eiffage TP JV
- ▶ **Methods:** JMB Méthodes
- ▶ **Specialized contractor:** Freyssinet



1

## HEBETEC: FROM LIFTING TO SLIDING

Hebetec, the world specialist in heavy lifting acquired by Freyssinet in 2004, has been developing two processes to expand its range of sliding techniques since 2000: the APS (AirPad-transport-System) and the Megasteel systems. The APS process is based on the use of lifting jacks with an air pad fitted around the base. After the load is taken up by the hydraulic system, high-pressure nitrogen is injected into the air pad, creating an air cushion so that the load and supporting structure can be easily slid. Originally used to move ships under construction on shipbuilding sites (3), the procedure was adapted to move engineering structures following Hebetec's acquisition. Similar to a building block, the Megasteel system can be used for all types of shoring configuration using fewer profiles with a 150 to 2,000 kN capacity.

The two systems were combined to slide an overpass into place at Forges-les-Eaux (Seine-Maritime) for SNCF in August 2006. Unlike structures moved by Autofonçage or Autoripage, structures moved using the APS process sit on two supports rather than on a raft. Taken up by the APS units (2) and by means of equipment, the 1,300 tonnes of the structure are supported by two 45 m reinforced concrete stringers serving as rails (1). The larger soil stresses engendered by this process are exerted on soil types with good bearing properties.



2



3

SOILS/KAUST UNIVERSITY

# 2,700,000 m<sup>2</sup> of soil consolidation in eight months



The construction of the KAUST University in Saudi Arabia required the consolidation of an exceptionally large platform. To meet this challenge, Ménard used extraordinary human and technical resources.

**N**AMED KAUST, SHORT FOR THE KING ABDULLAH UNIVERSITY OF SCIENCE & TECHNOLOGY, the university complex under construction on the banks of the Red Sea in Rabigh, 80 km north of Jeddah, is currently a flagship development project in Saudi Arabia. When open in September 2009, this university will welcome top researchers from all over the world, researching the scientific and technological challenges of the 21st century, and 2,000 students spread out over a 3,600 ha campus. Launched by the Saudi government, the project management has been awarded to Aramco, the national oil giant, and is supervised by the Ministry of Oil and Mineral Resources. The ultimate aim, however, is for this university to be completely independent. "At the beginning of 2007, we met with the Aramco teams, who had sought our advice: the improvement of the soil was the critical path of the project," explains Marc Lacazedieu, assistant managing director of Ménard. We helped them define the specifications for the soil improvement work in order to minimize the need for conventional pile foundations

as far as possible and therefore make important time savings." The tender for work to prepare the platform and the earthworks launched subsequently was awarded to two companies, Al Khodairy and Saudi Binladin Group, who sub-contracted the work to Ménard.

**13 cranes in action**

"We are the only ones who were able to satisfactorily meet the principal technical criterion, which stipulated that the soil improvement work should allow for the construction of buildings with loads of up to 150 tonnes at any point of soil because the exact location of the loads was not known in advance, meaning a pile solution was unrealistic," points out Pierre Orsat, in charge of export development at Ménard, who negotiated the work. In its solution, Ménard proposed a combination of dynamic compaction, dynamic replacement, using as many as 13 compacting cranes simultaneously, equipped with weights of 13 to 20 tonnes, and two drilling teams to identify the soil type and therefore the treatment method and verifying the improvement results following



the work. "The presence of a shallow water table and the soil type meant that work also had to take place in various phases, representing up to five work phases for the same area, leaving the soil to rest between each phase," explains Arnaud Meltz, project technical lead for Ménard.

The contract initially awarded to Ménard consisted of improving an area of 1,450,000 m<sup>2</sup> in eight months, this period also including the mobilization of the personnel and equipment. Since the start of the work, this area has been significantly expanded by the client to 2,700,000 m<sup>2</sup>, to be improved within the same deadline. To successfully complete this exceptional project under the supervision of the project manager Michel Piquet, Menard brought more than 110 people to the job site working

at double shift, with a management team consisting of ten engineers. The site was home to many different cultures and nationalities, with people from France, Germany, Turkey, Egypt, the Yemen, Iran, Pakistan, Malaysia, Singapore, the Philippines, Indonesia, Syria and Saudi Arabia. ■

**PARTICIPANTS**

- ▶ **Owner:** King Abdullah.
- ▶ **Project manager:** Saudi Aramco.
- ▶ **Main contractor:** Al Khodairy (zone 1), Saudi Binladin Group (zone 2).
- ▶ **Specialist contractor:** Ménard.



The 110-strong team brought to site for this express project used a combination of Ménard techniques in temperatures that could exceed 45 °C in mid-summer.

SOILS & STRUCTURES/PROJECTS IN THAILAND

# Construction, repairs and Reinforced Earth



Around Bangkok, as part of major development work, Freyssinet Thailand, after completing the SOBRR cable-staying this summer, is unfaltering.

WITH THE SATURATION OF THE ROADS in the south-east of the Thai capital, the country's authorities recently decided to strengthen the mass transit infrastructures and launch a project to extend the light aerial rail system, more commonly known by the city's inhabitants as the Bangkok Mass Transit System (BTS). Part of this project was the construction of a 5.25 km long and 8.60 m wide aerial viaduct, consisting of 156 spans made of precast segments, linking the Onnut and Bangna districts. "This structure will have five stations," explains

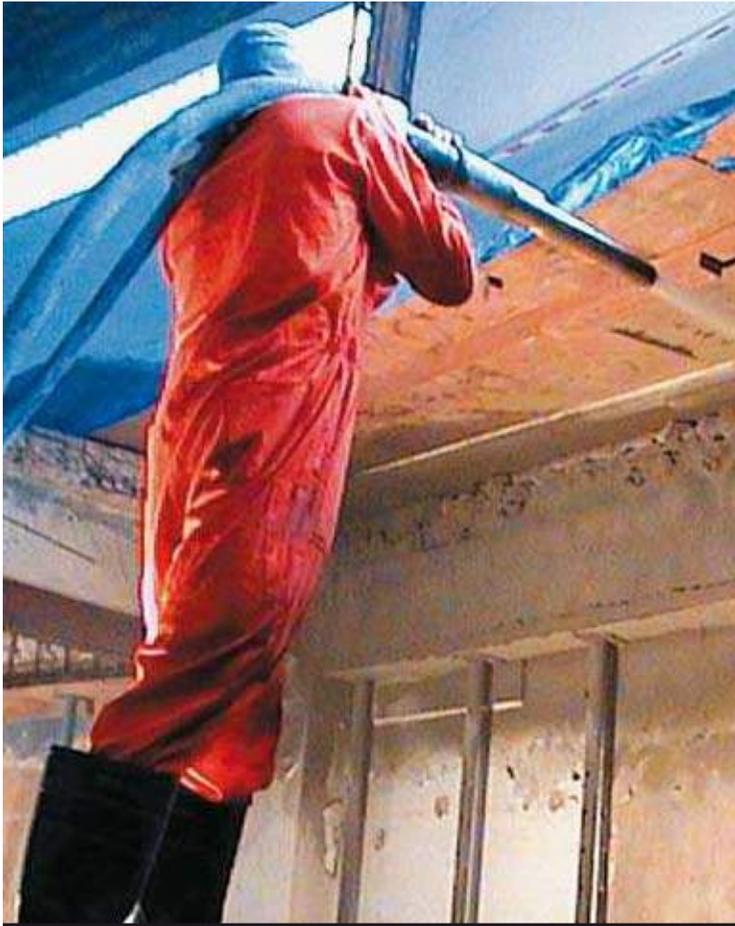
Komgrid Jomvenya, Construction Director of Freyssinet Thailand, "and we've installed 940 tonnes of prestressing for the superstructure, 2,090 19C15 anchors, 104 12C15 anchors and 232 prestressing bars to fix the pier segments. 120 tonnes of prestressing have also been installed for the station crossbeams, in addition to 920 anchors."

**Shotcrete strengthening**

Several kilometres north of the capital, in the province of Nonthaburi, Freyssinet Thailand was also involved in the project to repair

the Nang Klao bridge, a reinforced concrete cantilevered structure crossing the Chao Praya river. Freyssinet was asked by the main contractor to strengthen the underside of the slab of pier n°16 located on the river bed – a shotcreting operation carried out from a cradle. In Phuket, in the south of the country, the same technique was used prior to converting the Phuket Shopping Center, one of the first shopping centers built on the island, awarded the prize for the most attractive architectural project in Thailand in 1982. With tourism and trade flou-

rishing on the island, the owner of the complex decided to preserve the building's architectural façades but convert the interior into apartments following renovation. "We were awarded the contract for the reinforcement and repair of the structure," explains Borvornbhun Vonganan, Managing Director of the Thai subsidiary. "Using shotcrete and additional reinforcements, we strengthened 220 m² of slabs, beams and columns between August and September 2007." ■

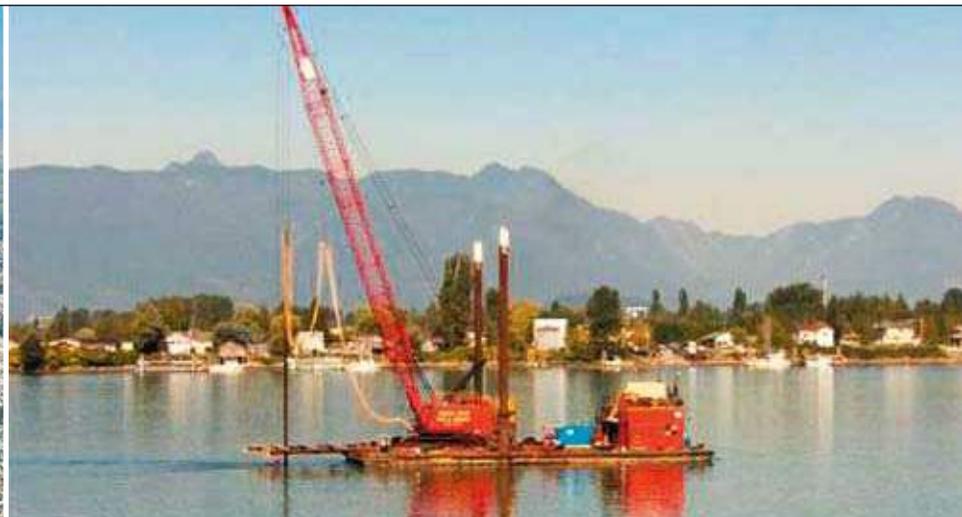


## 17,450 m² of Reinforced Earth



Not a moment's rest in Thailand for the Group's Reinforced Earth division. Through its Reinforced Earth division, Freyssinet Thailand was awarded the design and build contract for four walls (representing a total area of 17,450 m²) on motorway n° 7 (between Chonburi and Pattaya, south of Bangkok) which is currently being extended. The work began in January 2007 and was completed in October.

- PARTICIPANTS** • **Owner:** Department of Highways  
 • **Main contractor:** United Construction Company Ltd  
 • **Specialist contractor:** Freyssinet (Thailand) Ltd.



## SOILS/GOLDEN EARS BRIDGE

# Solid foundations for the piers

**A**FTER ONE YEAR OF WORK, Géopac, the Group's Canadian subsidiary, as part of a joint venture with Fraser River Pile and Dredge Ltd, recently completed the ground improvement work required for the piers of the new Golden Ears Bridge situated just outside Vancouver, British Columbia. "In order to increase the density of the Fraser River bed, we proposed to use vibro-compacted columns as an alternative to the Stone Columns solution using bottom feed system" says Pierre Lépine, Director of the subsidiary. Bilfinger Berger-CH2MHILL Joint Venture

chose this alternate because not only it was more economical but also it was faster. Working from a barge for the marine portion, the columns were positioned using GPS. The technique used consisted of compacting the ground in situ using a vibrating probe called the V23. Fixed to follow up tubes, this tool is lowered to the desired depth by the combined effect of vibrations and projecting high-pressure water and compressed air from the end of the equipment. The vibrating probe is then raised in stages of 0.50 m. Water and compressed air are also

injected onto the sides of the tubes to get the in situ soil to "drop" down to the vibrating probe, which will then compact it. After compaction, Settlements of 1.50 to 2 m have been recorded.

### "Wet top feed" columns

For the land section, at the North and South bridge abutments, the ground was densified using traditional wet top feed stone columns technique. "Nevertheless, they were installed to a depth of 35 m, which has rarely been achieved in Canada," points out Samuel Briet, engineer at

Géopac. The process was similar to the one used for the marine portion, but required the addition of ballast. The combination of high-pressure water and compressed air creates an annular space between the following tube and the ground that is used to convey the ballast from the working surface to the vibrating probe where it is compacted in stages. The diameter of the stone columns was generally between 0.80 and 1 m, representing a soil density increase of 8 to 10 %. A total of approximately 300,000 m<sup>3</sup> of ground was improved. ■



STRUCTURES/GEMENEA BRIDGE

# Repairs – a successful alternative



**Promoting the benefits of repairs and its expertise in this field, Freyrom, the Group’s Romanian subsidiary, convinced the authorities to repair rather than demolish the Gemenea bridge.**

**F**AMOUS FOR ITS ORCHARDS, THE NORTH OF WALLACHIA, less than 100 km north-west of Bucharest, exports its apples all over the world. A large number of tractors and lorries therefore cross the region and use the Gemenea bridge over the Dumbovita river. This structure, built in 1964, had deteriorated to such an extent that the authorities had decided to

demolish it. “Having successfully restored other structures, notably the Comanesti and Tomsani bridges in 2006 as part of the R14 program (see S&S n° 223, p. 24), we explained to the authorities that the bridge was in fact repairable and that we had the technical skills to carry out the repair work, and we managed to convince them,” proudly explains Dimitri Plantier, general manager

of Freyrom, who stresses that “sustainable development always gives preference to repairs over demolition where possible”. The 123 m long Gemenea bridge consists of a 6-span deck sitting on five piers and two abutments. At the end of 2006, work began with the creation of new foundations and the injection of 800 micropiles with cement grout. The piers were then raised and repaired

and the pier crossbeams repaired using Freyssibar prestressing bars. The underside beams were then rebuilt using shotcrete (3,000 m<sup>2</sup>). “We effectively altered the static plan of the structure in order to strengthen it,” says Thierry Robert, the site supervisor. After this, repairs to the deck could begin. “Since the structure was a key part of the region’s infrastructure, the repair method chosen allowed for traffic flow to continue during the work, thereby saving the drivers, carriers and inhabitants a 50 km detour in order to cross the Dumbovita,” continues Thierry Robert. “We adopted the necessary measures

STRUCTURES/SANTANDER BRIDGE

# Noteworthy technology at the entrance to the technology park



Freyssinet has carried out the cable-staying of the access bridge, a symbol of modernity and technical expertise, to the technology park under construction in Santander (Spain).

ON THE OUTSKIRTS OF THE CITY OF SANTANDER, a vast technology park is under construction on the Spanish coast of the Bay of Biscay. Situated between the Cantabria motorway and the beaches of Sardinero, near the university campus, this project is the fruit of a four-year plan launched by the Autonomous Community of Cantabria to promote the region's technological research & development activities. Since access to the park required the crossing of an express road, the project promoters chose to build a bridge that symbolised their ambitions. Work on this cable-stayed structure with ultra-contemporary lines has just been completed, for which Freyssinet designed and installed the stay cables.

The 97 m long and 22 m wide bridge has two lanes in each direction, two walkways and a 2.40 m central reservation. Its sloping steel pylon peaks at 31.30 m and receives the top anchors of three planes of stay cables: two, in a V-shape, consist of six retaining cables anchored on each side of the road. The other, towards the front, consists of nine stay cables anchored every six metres on the structure's central reservation. Freyssinet put its specialist cable-

staying skills to work and supplied and installed the 42 tonnes of steel for the stay cables. Each consisted of 31 to 37 strands benefiting from triple individual protection: galvanized, wax-protected and white polyethylene exterior sheath. The front and rear cable anchoring followed a different principle: the nine stay cables at the front are anchored by means of fork end to the deck and adjustable anchors to the mast, while the retaining cables, towards the rear, are fixed by means of a fork end to the pylon and equipped with low adjustable anchors.

Freyssinet used its patented Isotension® process, applied strand-by-strand, to tension the stay cables. It took the company just eight weeks to complete the threading and the tensioning of the stay cables. ■



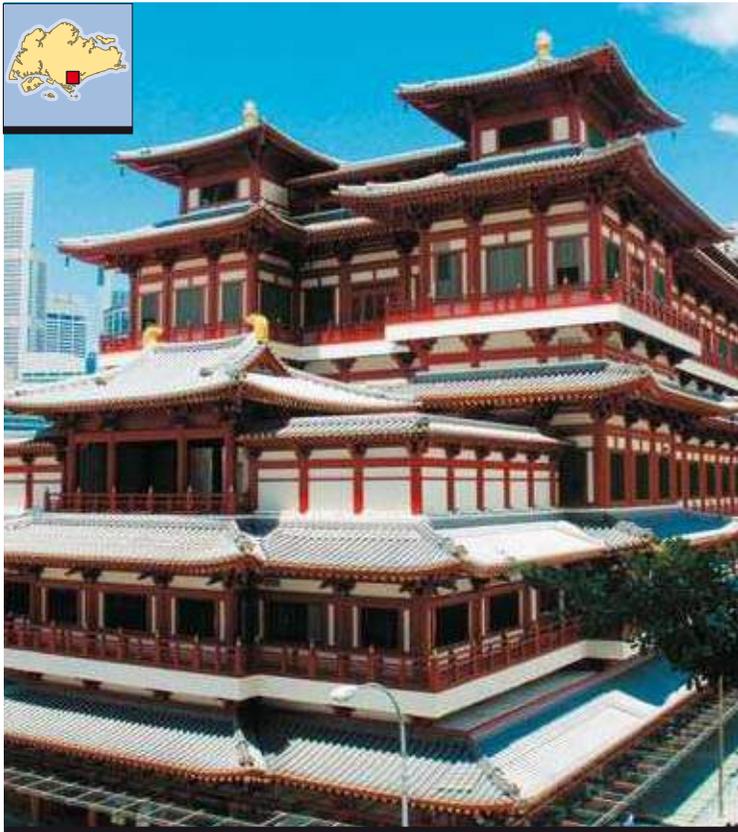
to maintain traffic flow along half the roadway during the deck repair work." The 40-strong Freyssinet and Freyrom team installed 65 tonnes of steel reinforcements and 400 m<sup>3</sup> of road concrete. To complete the work, the structure will be given additional longitudinal prestressing in the form of 10 7C15 cables. ■

## PARTICIPANTS

- ▶ **Owner:** National Company of Motorways and National Roads.
- ▶ **Main contractor:** Freyssinet.
- ▶ **Sub-contractors:** Emfor Montaj (foundations), Procor SA (deck), SC Vlad Tepes (coated materials).

## PARTICIPANTS

- ▶ **Owner:** Sociedad Gestora PCTCAN.
- ▶ **Design:** Arenas y Asociados.
- ▶ **Builder:** Ascan. Empresa Constructora SA.
- ▶ **Specialist contractor:** Freyssinet.



STRUCTURES/SINGAPOREAN TEMPLE

# Prestressing at the service of Buddhist architecture

**N**EAR SOUTH BRIDGE ROAD, at the heart of Singapore's Chinese quarter, the designer of the new temple of the Sacred Relic of the Tooth of Buddha has largely used Freyssinet prestressing to build the structure. Consisting of a four-storey building with a mezzanine floor and a small roof terrace, "This is one of the country's top tourist spots," explains King-Ing Siau, Construction Director of Freyssinet Singapore, who points out that "the use of prestressed beams afforded the creation of large spaces without columns in the large prayer hall and the activities rooms, which are open to tourists, the public and Buddhists alike." With a span of some 20 m, all the beams span the

width of the building and support a reinforced concrete slab. Nearly 30 tonnes of strand steel were used for the whole project. "Our work is now complete, and we've stepped aside so that the finishing work to the building's internal and external façades can take place. They're being given a beautiful treatment in traditional Buddhist style," finishes King-Ing Siau proudly. ■

**PARTICIPANTS**

- ▶ **Project manager:** Sato Kogyo (S) Pte. Ltd
- ▶ **Consultant:** T&T Engineering Consultants.
- ▶ **Specialist contractor:** PSC Freyssinet (S) Pte Ltd

STRUCTURES/PUERTA DEL PUENTE

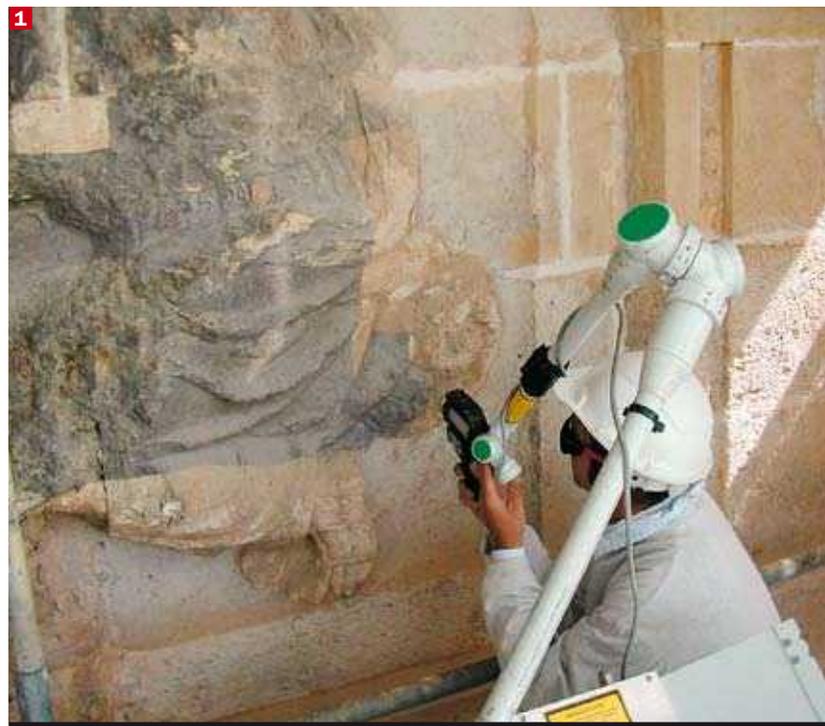
# Makeover on the banks of the Guadalquivir



Freyssinet's Spanish subsidiary, the specialist in restoring historic monuments, took part in a major project to repair the monuments of the city of Cordoba.

**O**N 10 MARCH 2007, IN CORDOBA, the president of the Assembly of Andalusia, Manuel Chavez, opened the Puerta del Puente (bridge gate) in Cordoba, newly renovated by Freyssinet S.A., through its Southern Branch, which was awarded all the work. Situated on the site of an ancient Roman gate altered at the time of the Arab conquest, the Puerta del Puente has been repaired and restored many times over its history. One of

the most important, which gave the monument its current style, dates back to 1570. To commemorate King Felipe II's visit to Cordoba, the existing monument, with its marked Arabic symbolism, gave way to a Renaissance cal-carenite\* structure topped by a semi-circular piece on which the coat of arms of the royal Hapsburg dynasty is sculpted. The most recent transformation dates back to 1928. The north façade was altered, trans-



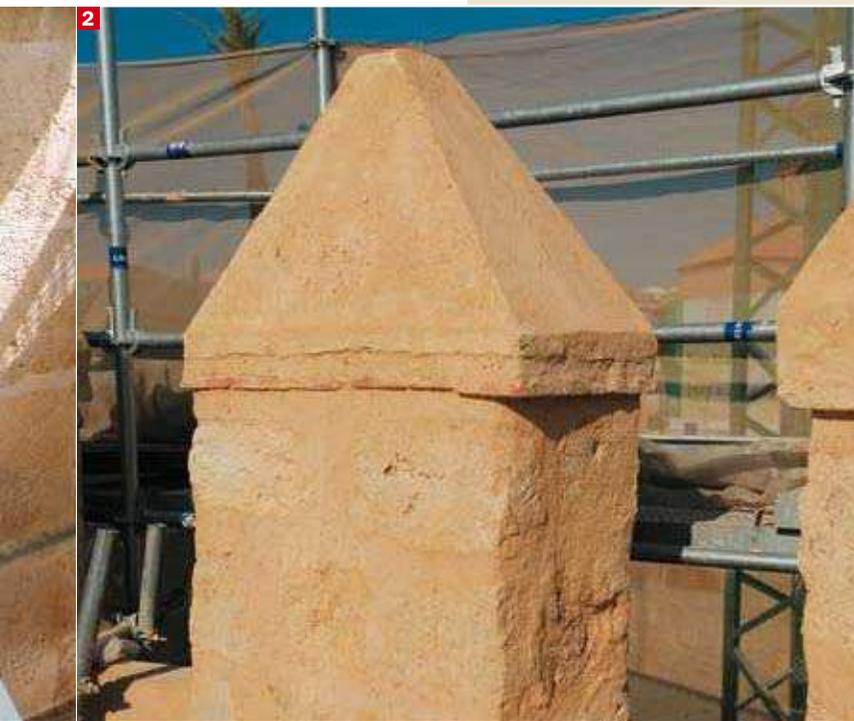
forming the monument into the stand-alone triumphal arch that can be admired today.

The gate had severely deteriorated: loss of material, stone suffering from honeycombing, erosion, cracking and spalling. The far older south façade was particularly affected, suffering notably from the effects of pollution, adverse weather, damp caused by the Guadalquivir and damage caused by birds. Following an evaluation and archaeological study of the structure, Freyssinet SA used a wide range of techniques to carry out the restoration work. The relief work sculpted into the outside was cleaned using lasers and the free stone using microwax cutting tools; the material lost from the stone was reconstituted using mortar and the stone consolidated; waterproofing compounds were applied over the façade, while an electronic dewatering system was installed to prevent damp. An electric system on the roof and close to the columns also prevented birds from causing further damage. Finally, the interior of the arch was converted to create an exhibition space and a panoramic viewpoint.

The rehabilitation work, however, is not complete. It is scheduled for completion in 2008 with the development of the area surrounding the monument. Freyssinet SA has now started restoration work on the Torre de la Calahorra, extending over 20 months – a project that forms part of the general schedule of works that the Assembly of Andalusia has implemented to restore the monuments of the city of Cordoba. ■

*\* Local limestone rock, of a sedimentary origin.*

**In Cordoba, Freyssinet SA used a wide range of techniques to restore the Puerta del Puente, which had suffered the ravages of centuries of history: laser (1) and microwax cleaning, reconstitution of stone with mortar (2, 3), consolidation, waterproofing, electronic dewatering system, etc.**



SOILS/TECHSPAN ARCH MINING TUNNELS

# At the test of the mine tips



The TechSpan precast arch system, perfectly suited to mining activities and the construction of conveyor tunnels, has recently been used in two major projects in Australia.

**O** PENED IN 2001, NEWPAC NO. 1 COLLIERY (NEWPAC) is an underground coal mine situated in Hunter valley in New South Wales. Exploited by heading (parallel tunnel driving) and extraction (separation wall working), the mine harbors 252 million tonnes of coal reserves and produced 1.1 million tonnes of raw coal in 2006. To increase production to 4 million tonnes per year from January 2007, the operator launched a development plan that involved the installation of longwall face equipment, the modernization of the underground conveyors, the renovation of the coal preparation plant and the creation of new raw and “finished” coal tips. Two new conveyor tunnels also needed to be built to transport the raw coal and the clean, finished coal. The first tunnel, 79 m in length, had to have three chambers, one of these being for the bucket system, and five chutes fitted with valves for feeding the conveyor, situated downstream of the storage tip. “As we normally do for this kind of application, we proposed that we build these structures using the TechSpan precast arch system, combined with Reinforced Earth head and wing walls for the tunnel entrances,” explains Gary Power, Managing Director of the Reinforced Earth Australian subsidiary (RECo).

**Special cavities**

The construction of the tunnels began in August 2006. “This was a complicated project,” points out Gary Power, “as we had to determine and study the dynamic loads linked to the equipment movements, the variable loads on the arches based on the height and position of the



Two TechSpan arch tunnels have been built on the site of Mount Tom Price: one houses a receiving conveyor (see photo above) and the other an emergency exit.

At Newpac, the raw coal tunnel is 6.50 m wide, 3.90 m high and 79 m long. The “finished” coal tunnel is 160 m long, 6.50 m wide and 3.50 m high.



tip, and we had to account for major gradient differences in some of the tunnel sections.”

At five points of the 160 m finished coal tunnel, RECo also proposed the creation of cavities at the top of the arches to accommodate the tip’s conveyor discharge valves, which led to the design of an original truss system to assemble the arches and support the valves. This solution proved to be more efficient and economic than the heavily reinforced chambers in the form of caissons cast in situ commonly used in this type of configuration. To meet the tight construction deadlines, six precast arches were cast each day, an exceptional speed given the fact that the moulds had to be changed frequently to create the special elements.

#### **Between 19 and 20 million tonnes of iron ore per year**

On the other side of the continent, in Western Australia, Mount Tom Price is Pilbara’s oldest and largest iron ore mine. Commissioned in 1966, four years after discovering the deposit, a 8 km long and more than 1 km wide section of ore, this mine produces between 19 and 20 million tonnes of ore, renowned for its impressive physical and chemical properties, per year.

To meet fast growing market demand, the operator, Rio Tinto, decided to increase the site’s production by expanding its facilities, notably by constructing a new tip and a new storage silo.

Consulted for the purpose of designing and supplying the precast concrete tunnels housing the receiving conveyor and the emergency exit and a new reinforced concrete storage silo, RECo again recommended the TechSpan system, an all the more suitable solution given that the structures had to be built on an extremely isolated site, 1,000 km north of Perth and 300 km from the closest port, at the heart of a mining area that, although in full growth, was very congested since the extrac-

tion, crushing and the entire ore and discarded material treatment process takes place there.

The design of the tunnel elements, situated under the conical-shaped iron ore tip located above the tunnels, was one of the main difficulties of the project entrusted to the RECo engineers. This tip, which is as high as 30 m and weighs 2.5 tonnes/m<sup>3</sup>, is supplied by an aerial conveyor and moved by equipment with an unladen weight of 67 tonnes. “Again, the tunnels had to support the dynamic load of the equipment and the static load of the tip, and we also had to account for the fact that the shape of the tip was constantly changing due to ore being removed for export and ore being introduced by the equipment or conveyor,” explains Gary Power. “We therefore had to study different scenarios.” For the emergency evacuation tunnel, there was only one possible layout which involved a sharp-angle convergence of the evacuation tunnel and the storage silo. This led the RECo engineers to develop two special TechSpan arch shapes using in-house finite element analysis software. ■

#### **PARTICIPANTS**

##### **Newpac receiving conveyor tunnel**

- ▶ **Owner:** Newpac Mine.
- ▶ **Client:** Roche Process Engineering.
- ▶ **Design firm:** Roche Process Engineering Haald Engineering.
- ▶ **Tunnel builder:** Civil Build.

##### **Tom Price receiving conveyor and evacuation tunnels**

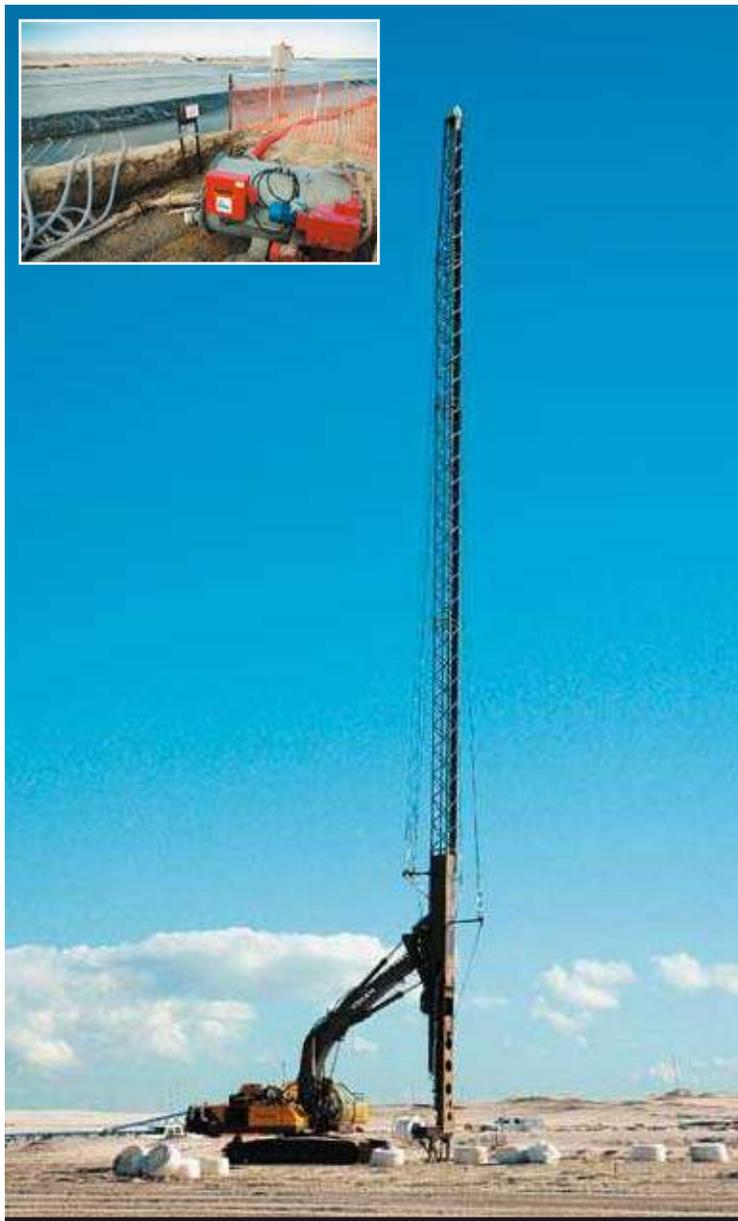
- ▶ **Owner:** Rio Tinto.
- ▶ **Design firm:** Aker Kvaerner.
- ▶ **Project manager:** Civmec.

SOLS/PORT OF FISHERMAN ISLANDS

# Menard Vacuum Method in competition for the port expansion project in Brisbane



A short while after the first trial in Australia, on Ballina project (see “S&S” n° 225), the Menard Vacuum Method is again proposed by Austress-Menard, for a major project to expand the port of Fisherman Islands.



**O** PEN ON THE PACIFIC OCEAN AND EAST OF ASIA, the south-east region of Queensland and the capital city Brisbane are in rapid development and need to build the infrastructure essential to sustain their increased trade growth. Port of Brisbane Corporation (PBC), the managing authority of the Port of Fisherman Islands, located at the mouth of the Brisbane River, is planning to quadruple the capacity of the port facility by 2020. A huge dyke has already been constructed in the early 2000's to contain the 235 ha of the future land reclamation, which will be carried out using dredged materials from the Brisbane river. Under the new reclamation, the depth of the soft marine deposits is such that consolidation of the subsoils could not be achieved, in a reasonable time, by the simple method of preloading, as used previously by PBC. Therefore, in order to select the best suited accelerated ground improvement techniques, PBC invited in early 2006, expressions of interest from specialist ground improvements contractors to design and carry out full scale trials in the existing reclaimed land. Selected with Boskalis and Van Ord, Austress Menard proposed the use of the widely proven method of prefabricated vertical drains ( PVD's ) plus fill surcharge, and also the use of

atmospheric consolidation (Menard Vacuum Method) for the site edges, potentially unstable under a substantial fill thickness.

In October 2006, PBC awarded the contracts to the three applicants to perform their PVD's trials in areas of 3 ha each. An additional area of 15,000 m<sup>2</sup>, was allocated to Austress-Menard, for the trial of the Menard Vacuum Method.

## Trials performance

Dealing with the most difficult area (see boxed text), Austress Menard designs were carried out on the basis of a very comprehensive soil investigation conducted in situ and in laboratory by Coffey Geosciences, PBC's geotechnical consultant. The residual settlement criteria is 250 mm over a 20 years period under a live load of 1.5 tonnes/m<sup>2</sup>. The PVD trial area was divided into six sub-areas and optimized to achieve consolidation over a 12 months period, for different drains types, spacings and surcharge heights. Adjacent, the Vacuum L shaped trial area is located along the environmentally protected west and south borders of the reclamation. It is specially designed to ensure stability of the high fill surcharge over the PVD areas. The first phase of the site works was the rectification of the working platform to allow safe traffic of the heavy plant (up to 80 tons) used for cut-off wall and drains installation. This involved removing excess mud at some places and placing sand where missing to ensure a minimum 2m mat at all locations. The biggest challenge of the works was undoubtedly the construction of the 15m deep vacuum perimeter cut-off wall. Rich of the expertise gained on the previous Tempe Tip and Mayfield jobs, Austress-Menard has used the same technique of the soil-bentonite wall. However owing to the particularly severe soil conditions and the stringent -1bar vacuum depression, a geo-liner was installed in the upper part of the wall to reinforce its air/water tightness.

## Extreme soil conditions

Austress Menard have inherited of particularly difficult soil conditions in their trial area. The depth of the original soft clay, above the substratum varied greatly, reaching 34 m at the deepest points. On top of the soft clay the original seabed consisted of 4 to 5 m of sandy marine deposits, highly permeable. This has necessitated the construction of a deep perimeter cut-off wall to isolate the Vacuum zone. Above the seabed, the hydraulic fill reclamation, carried out from 2003 to 2006, had resulted in very uneven layers of mud and sand. At time of placing the nominal 2m sand capping, the quasi fluid mud had been displaced in waves towards the south; as a result the sand working platform could be as thick as 8 m in some places and completely absent in others, as in the south-west quarter.

An other challenge of the project, was the installation of 750,000 ml of vertical drains, to an unprecedented depth in Australia of 35 m, within the short allocated 2 months time. Thanks to the mobilization of two rigs- one being from Korea- the operation was finished on time, by mid April 2007.

### 6 months at -0.8 bar

Thanks to the experience gained on Ballina project, Austress Menard's team had no difficulty to install the vacuum system; vacuum pumping has commenced on 9 June 2007 for a designed operation period of ten months. Six months later, the depression under the membrane is still at a record level of - 0.8 bar, no noticeable leak being observed.

### Preloading and monitoring

The next step was the placing of the fill surcharges, by PBC, over the trial areas. Due to fill heights as much as

6m to 8m on the PVD areas the fill installation was only completed in November 2008; thanks to the help of the atmospheric pressure the requirement was only for 2.2m of fill over the Vacuum membrane, which could be completed in a short time before mid-August

From the start of the trials, settlements and instrumentation data are collected by Coffey Geosciences and analyzed at regular intervals by Austress Menard. The end of consolidation is forecast in April 2008 for the Vacuum trial, and in June 2008 for the PVD trials. June 2008 is also the time scheduled by PBC to review and evaluate the performance of the three Trialists and their proposed ground improvement systems. What is at stake is considerable, as the successful system and contractor may be retained for the ground improvement of 220 ha of the future port reclamation...



SOILS/ESCONDIDA COPPER MINE

## An unfailing wall

IN THE HEART OF THE ATACAMA DESERT IN CHILE, roughly 160 km south-east of Antofagasta, stretches the vast Escondida open-cast mine. This site, which has been operational since 1990, is the direct employer of more than 2,300 people and its production has grown constantly and today represents 20% of the copper pro-

duced in Chile, the number one world producer. To enable the dumpers to access crushers nos 2 and 3, a Reinforced Earth retaining wall has recently been erected. This 19.50 m high structure covers an area of 5,040 m<sup>2</sup>. "We designed and provided support with the assembly of the structure, which forms part of the Escondido W9 project. Work took five months, from April to August 2007," says Hector Ventura, Managing Director of Tierra Armada's Chilean company. "The wall is capable of supporting the movements of 600 tonne dumpers and accommodating a seismic acceleration of 0.40 g, one of the greatest stresses that can be applied to structures of this type."

### Reinforced Earth walls: ductile structures for earthquake resistance

Reinforced Earth frequently designs structures in earthquake areas. Reinforced Earth structures, made of a composite material, have properties that favor energy dissipation which is the basic principle of para-seismic rules i.e. a material with tensile and shear strength, simple and regular shapes and, lastly, closely connected elements forming continuous systems.

### PARTICIPANTS

- ▶ **Owner :** SKM Minmetal - BHP Billiton.
- ▶ **Specialist contractor:** Tierra Armada

STRUCTURES/MACINTOSH ISLAND FOOTBRIDGE

# A speed record on the Gold Coast circuit



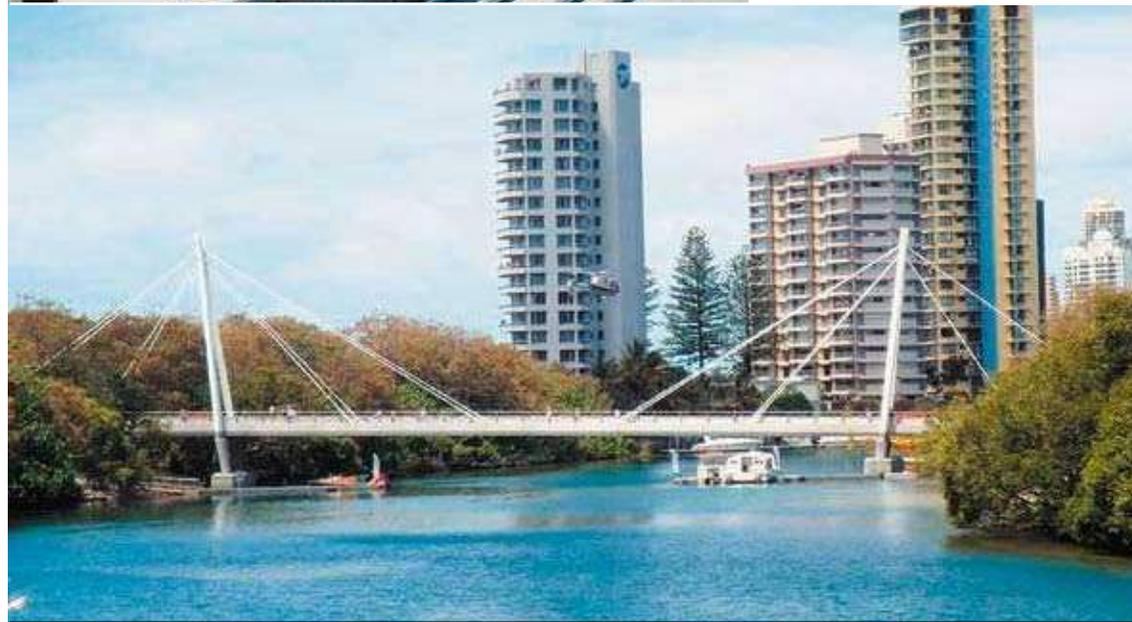
With the support of Freyssinet's Technical Department and PPC, Austress Freyssinet designed and built the new footbridge for the Gold Coast racing circuit (Australia) in 156 days.

THE CHAMP CAR WORLD SERIES, (THE US EQUIVALENT OF FORMULA 1), holds one of its races each Spring at the Gold Coast circuit in the State of Queensland.

In 2006, the Macintosh Island footbridge, a narrow wooden bridge within the boundary limits of the circuit, was at risk of collapsing under the weight of the specta-

tors. The local authorities decided to close the bridge and replace it with a new one before the 2007 race scheduled to take place on 18 October. Following a tender process, the joint venture formed by Austress Freyssinet and Ark Construction Group, its partner on the footbridge market since 2005, was awarded the contract on 15 May. The deadline to design and build the bridge was only 156 days – a real race against time was underway...

Drawing from its experience and methods on similar projects, the joint venture started the design and procurement process the day after signing the contract. Less than four days were needed to complete the architectural design and four weeks for the studies to build the



structure, a 110 m long bridge consisting of a deck and precast beams prestressed by post-tensioning. The bridge is supported by two steel pylons, 16 m high profiles, by means of 16 Freyssinet 7T15 H1000 dual anchoring stay cables (see boxed text). 14 June saw the start of the work to sink the prefabricated piles, while in France, Freyssinet's Technical Department and the PPC factory concentrated on designing and fabricating the 32 compact stay cable anchors, which could be delivered to site well before the start of the cable installation on 29 August. The installation and tensioning of the cables took place on schedule and the structure was finished and ready for the start of the race. ■

### PARTICIPANTS

- ▶ **Owner:** Hyder Weathered Howe.
- ▶ **Architect:** Cox Rayner Architects.
- ▶ **Project Manager & Main contractor:** Ark Construction Group Austress Freyssinet Joint Venture

### H1000: the stay cable for light structures

Smaller than the HD range of high-capacity cables, the Freyssinet H1000 stay cable has been developed for light structures such as footbridges or roofs. Its fatigue and corrosion-resistance properties however are identical to those of its bigger brothers. The H1000 compact sheath used with this stay cable is respectful of its more refined appearance and is suitable for use with all types of anchoring systems.

## STRUCTURES/ OULIANOVSK BRIDGE

# Lifting on the Volga



Freyssinet and Hebetec began lifting operations in August 2007 to install the spans of a new bridge crossing the large Russian river.

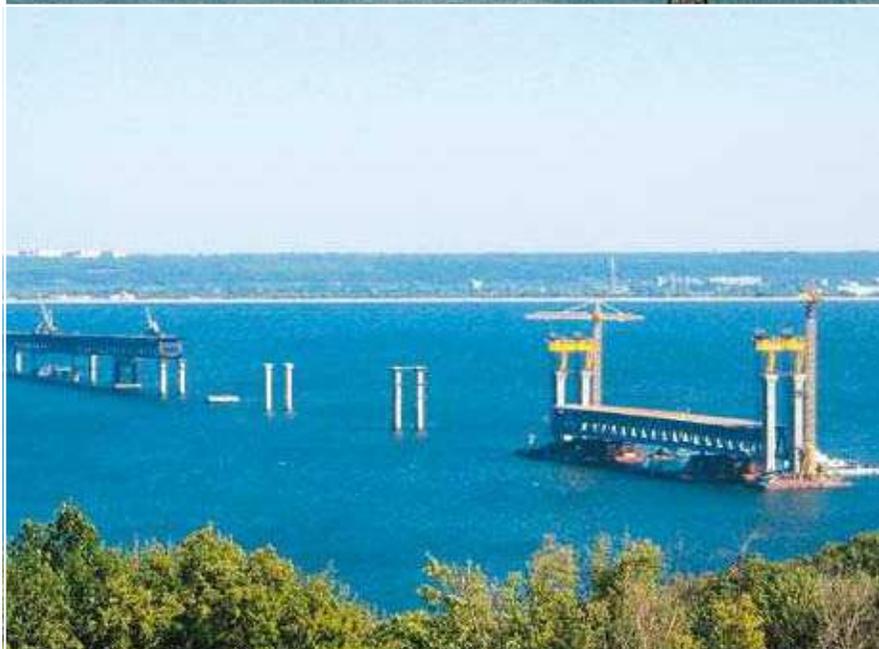
**N**EAR OULIANOVSK, 600 KM SOUTH-EAST OF MOSCOW (Russia), Freyssinet is involved in building a new bridge over the Volga, a very high piersed structure whose five steel spans were installed by lifting.

Freyssinet, who was asked to carry out the studies, design and manufacture of the lifting tools (supporting beam attached to the deck and jack-supporting carriage), worked in synergy with its Swiss subsidiary Hebetec, specialist in handling and moving heavy loads. Hebetec supplied the jacks and seconded an engineer to provide on-site technical support.

The 21 m long and 13 m wide trapezoid-shaped spans each weigh 4,200 tonnes. After being assembled on the ground, they were

transferred by barge to the vicinity of the piers before being lifted 45 m using 16 H400 jacks with a 4,000 kN capacity. Hoisted slightly out of position from their final bearings (one of the deck's longitudinal beams is situated between the two piers and the other to the outside), the spans then had to be slid over 4 m using four 140 tonne jacks before being lowered onto their bearings. Each operation took approximately one day.

After a series of tests took place on dry land during May 2007, the first real lifting operations took place in mid-August. Two further operations were scheduled to take place before the end of 2007. ■



STRUCTURES/MAAMELTEIN BRIDGE

# 8 months to repair the ravages of war



With expertise in a comprehensive range of repair techniques, Freyssinet has successfully repaired the Maameltein bridge in the Lebanon, which was damaged by bombs in 2006 and destined for demolition.

SOME TWENTY KILOMETERS NORTH OF BEIRUT, the Maameltein bridge, also known as the Casino bridge (the bridge is very near the Lebanon Casino), is one of the many “victims” of the military confrontations that marked the summer of 2006 in the Lebanon. Crossing a 70 m deep valley and overlooking the Bay of Jounieh, in a tourist area with a high population density, this reinforced concrete bridge was built between 1963 and 1965 and consists of two separate structures, each comprising 2 arches with a span of 95 m supporting a 13 m wide deck. The main damage was to the centre of the deck, where bombs had destroyed half an arch



on the upstream deck and one and a half arches on the downstream deck. “The structure was pretty much unstable and was at risk of collapsing,” explains Raja Asmar, Project Manager at Freyssinet, “and closing it would have caused great disruption to the region as it is one of the key links of the country’s north-south motorway section.” Believing the structure couldn’t be salvaged, the Owner and the Lebanon Casino had initially planned to demolish the bridge. Convinced that the bridge could be repaired, “and would also save more time and money than demolishing it, as well as being better for the environment,” points out Raja Asmar, Fre-

yssinet managed to convince them of this and was awarded the contract as main contractor in a consortium. The upstream deck could be repaired while maintaining partial traffic flow. However, repairs to the downstream deck which was more seriously damaged, required the bridge to be closed to road traffic. Freyssinet initially advanced by small steps, progressively increasing them to gradually secure the structure using horizontal cables and stay cables, which held the two front parts of the arches cut in mid section. These were then repaired and jacked up in the key in order to re-establish the natural thrust of the arch before re-building the deck. Work began in November 2006 and was completed in July 2007. ■

**PARTICIPANTS**

- ▶ **Donor:** Lebanon Casino.
- ▶ **Owner:** Development and Reconstruction Council.
- ▶ **Project manager:** Dar Al Handasah Nazih Taleb & Partners.
- ▶ **Design firm:** Gicome/ Setra/ Freyssinet.
- ▶ **Main contractor:** Freyssinet-Butec consortium.

STRUCTURES/CREMORNE WHARF PONTOON



# A refloated pontoon in the harbour of Sydney



VIOLENT STORMS BATTERED SYDNEY (AUSTRALIA) LAST JUNE, causing major damage to

the harbour. A 10 m long and 8 m wide pontoon weighing 260 tonnes was torn off its piles, collapsed and

then sank, and water had got into seven of its compartments. The heavy lifting operation required to reposition the structure was quickly entrusted to Austress Freyssinet. This delicate operation took place at night, the optimum time since there was less harbour traffic and the weather conditions were more favorable. After being assembled and tested on dry dock, the lifting platforms were trans-

ported by barge to the site of the operation. Once the barges were in position, the lifting beams were installed. Next, the clevis supplied by the Brisbane office was submerged before a team of divers fixed a sling\* under the pontoon and checked it remained horizontal. Finally, the lifting operation took place. The pontoon was lifted 10 m using four jacks with a 180 tonne capacity and the water was evacuated to keep the structure at the surface. The operation lasted 10 hours. ■

\*Piece of lifting gear made up of ropes, a cable, a chain or a strap of variable length which, as a rule, ends in one or two loops or hooks.

The height of the transfer slabs (2.20 or 3.50 m) meant the reinforcement work had to be combined with the installation of the prestressing sheaths.



## STRUCTURES/ VENETIAN PROJECT



# Savings of 18,000 tonnes of passive reinforcements

In Macao (China), as part of the project to build the second phase of a Mega-Casino development, Freyssinet Hong Kong supplied and installed more than 1,500 tonnes of floor prestressing steel.

ON THE COASTLINE OF THE SOUTH CHINA SEA, the city of Macao, returned to China in 1999, is well known for its casinos, which attract millions of gamblers each year. This financial manna, which represents more than 40% of local GDP, has earned the city the nickname of the Asian Las Vegas and has given rise to many development projects, such as the second phase of the Venetian project, the execution of which represents 700 million Hong Kong dollars (63 million euros). Situated on the Cotai strip, an area dedicated to leisure reclaimed from the sea between Taipa Island and Coloane Island, this project is one of many involving casinos, luxury hotels, exhibition and convention centers, cinemas and other leisure

centers and focuses on the creation of underground parking, a 22-storey tower block housing a Four Seasons hotel, a 33-storey apartment block with concierge service and a four-storey structure housing a casino, specialty boutiques, the complex's administrative headquarters and a fitness club.

"We were involved from the early stage as technical advisers," says Michel Monballiu, Managing Director of Freyssinet Hong Kong, "and worked together with the Contractor Top Builder who understood the benefits and was open to the challenge to use this new technique to the Macao market." Although the conforming solution involved the use of reinforced concrete, Freyssinet Hong Kong proposed an

alternative based on a design and build solution using prestressing, a solution largely justified by the possible savings on the materials. Prestressed flat slabs were therefore planned for the two underground levels (80,000 m<sup>2</sup>), primary and secondary prestressing beams for the three levels of Podium (approximately 51,000 m<sup>2</sup>) and so-called transfer plates for the hotel tower (2,750 m<sup>2</sup>) and the Serviced apartment Tower (3,700 m<sup>2</sup>). Transfer plates, which are often used in Asia, separate the underground level from the superstructure and their generally large thickness (2.20 m for the hotel tower and 3.50 m for the building) allows for the upper loads to be distributed independently of the lower loads.

### A project in synergy

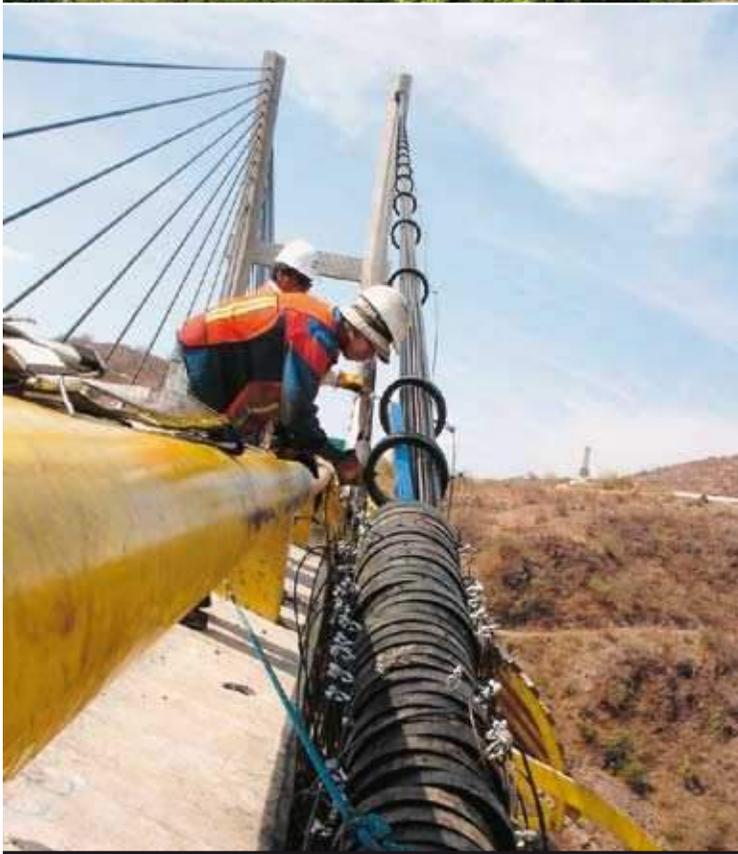
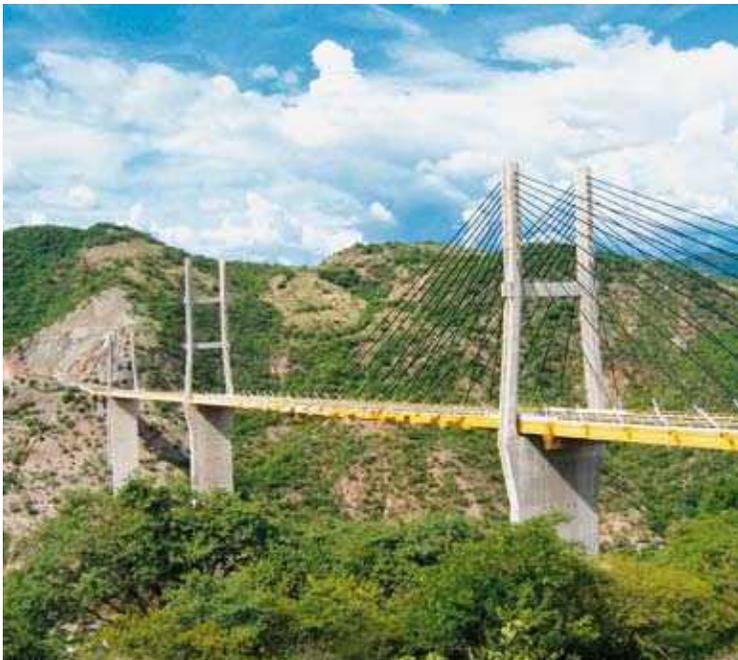
The scale and complexity of the project led Freyssinet Hong Kong to seek expert assistance from the design office of the Australian subsidiary Austress Freyssinet and an external design firm for the transfer plates. "The design of the flat slabs of the underground levels were entrusted to Austress Freyssinet, the podium beams to Freyssinet Hong Kong and the transfer plates to an external design office we usually work with. The drawings were, in their main part, subcontracted to the Philippines, where no fewer than 18 designers worked together to finish the first submission documents, totaling some 280 plans in a three-week period," finishes Marissa Piolin, engineer and designer at Freyssinet Hong Kong. The prestressing, which began in 2006, was finished at the beginning of November 2007. For the entire project, Freyssinet will have supplied and installed a total of in the region of 1,500 tonnes of prestressing, representing savings of 18,000 tonnes of passive reinforcements! ■

STRUCTURES/MEZCALA BRIDGE

# Lightning-fast cable-staying repairs



Last Spring, Freyssinet de México was called upon to make safe the Mezcala bridge and repair only one stay cable damaged by fire in just 11 days.



**B**UILT IN 1993 ON THE RIO DE LAS BALSAS, the Mezcala bridge is the largest structure on the Cuernavaca-Acapulco motorway and, due to its size and cable-staying, one of the most impressive in Mexico. The 882 m long bridge consists of six spans and its deck is supported by 140 stay cables, the upper sections of which are fixed to three pylons, the highest being 250 m, and arranged on six planes.

On Saturday 17 March 2007, maintenance work near abutment 7 led to the closure of the road in the Mexico-Acapulco direction and traffic being diverted onto the two lanes travelling in the opposite direction. A serious accident occurred between a coach and a heavy goods vehicle and both caught fire near the last section of the second plane of stay cables. The intensity of the blaze, which could not be immediately contained, caused stay cable n° 11 to break, and damaged the sheath of stay cable n° 10. The scale of the damage required a quick response. Two days later, on 19 March, a site visit was organized by the SCT (Ministry of Roads and Transport), the project manager, Capufe, and Freyssinet in order to inspect and evaluate the damage and the work to be carried out. "The bridge had to re-open on 30 March for the start of the Easter vacation," explains Luis Rojas, Managing Director of Freyssinet de México. "Our teams were therefore on site from 20 March and work began the next day with the removal of the debris and the dismantling of stay cable 11." On the days to follow, operations would continue at as sustained a rate. On

the fourth day, the dismantling of the vandal-proof tube and the upper and lower anchors was completed. "On the fifth day, we sent the anchors, deflectors and packing glands to our factory in Santiago Tianquistenco so they could be inspected and repaired and the new replacements for the damaged parts could be produced. All these elements were returned to site the following day so that we could install the temporary stay cable strands," continues Luis Rojas.

### An urgent project

The seventh, eighth and ninth days were devoted to installing the temporary strands, which were tensioned using the patented Iso-tension process. Finally, over the following three days, the Freyssinet teams installed the vandal-proof tube, cleaned the site and repaired the paintwork of the damaged parapet. "Our cable-staying expertise meant we were able to start work on the bridge as a matter of urgency, make it safe and ensure it would be re-opened on 30 March so that the many holidaymakers travelling over the Easter week could reach their holiday destinations using the bridge," concludes Luis Rojas. ■

### PARTICIPANTS

- ▶ **Owner:** Secretaría de Comunicaciones y Transportes (SCT).
- ▶ **Project manager:** Capufe (Caminos y Puentes Federales).
- ▶ **Designs:** Euro Estudios.
- ▶ **Specialist contractor:** Freyssinet de México.

# THE STAY CABLE MULTITUBE SADDLE: A TECHNOLOGY WITH A MULTITUDE OF BENEFITS

Developed from a simple idea: running cables continuously across the pylons so as to simplify their design and reduce their dimensions, stay cable saddles have illustrated their architectural interest magnificently since 1977 in the slender lines of the Brotonne bridge. The first systems installed, derived from prestressing, were not completely satisfactory as the cement grout injection of the bare cables at the point of the saddle prohibited the individual replacement of the strands and was unable to provide lasting corrosion resistance. Other more structural problems were caused by the curvature imposed on the stay cable at the saddle crossing and due to the fact the cables weren't designed to transfer loads on their main run.

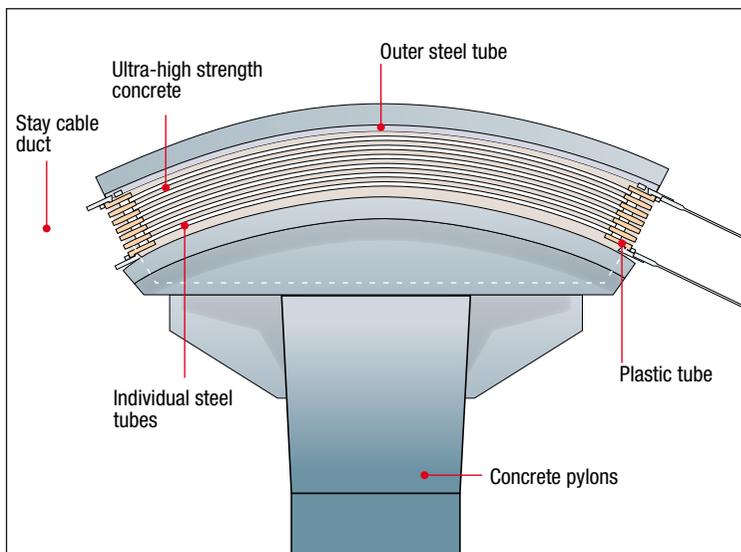
In order to overcome these drawbacks and meet the specifications of the Sungai Muar bridge (Malaysia), which demanded better performances in terms of service life, Freyssinet developed the stay cable multitube saddle at the beginning of the 2000's. "This solution was made possible thanks to the prior development of the "strand", or the Cohestrand, a cable whose polyethylene sheath, which is totally adherent to the steel wires, permits the transmission of differential forces by friction at the HDPE-tube interface," explains Erik Mellier, Technical Director of Freyssinet. Its second characteristic, which is a continuation of the first, is the use of ungrouted steel tubes that individually receive the strands. These 'multitubes', incorporated

## A first on a multi-span bridge

Split in two by the Daugava river, several hundred metres wide at just a few kilometres from its mouth, Riga, the Latvian capital, has completed the construction of a structure (see photo above), which will be the first multi-span bridge built with stay cables and multitube saddles, a variant proposed by Freyssinet as an alternative to the conventional grouted saddles initially planned. The 803 m long bridge is the key link of a new ring road destined to ease traffic flow on the city's other bridges. The structure was built on six piers spaced 110 m apart, onto which the steel deck was launched, equipped, like at Millau, with a launching nose supported by two stay cables supplied by Freyssinet. Next, the six 12 m high pylons, built before the concreting of the deck, were capped with 8 saddles supporting the 37 to 80 m long Cohestrand cables deployed on the centre plane. The orange colour chosen by the city for the deck and the cables led Freyssinet to carry out UV resistance and weldability tests for the stay cable sheaths.

in a high-performance fiber concrete structure, enable the radial compression stresses transmitted by each strand to be taken up, yet they remain free inside their tube before tensioning, however, making their individual replacement possible." Awarded the bronze medal in the 2003 Egis innovation awards, the applications of the multitube saddle have increased. In 2006, it was used in Vietnam (Nga Tu So bridge – 8 saddles), and in 2007 on four occasions: in the Sudan (El Mek Nimir bridge – 12 saddles), in Korea (Shindae bridge – 16 saddles; Po Nam bridge – 6 saddles) and in the Latvian capital Riga (see boxed text). Architecturally speaking, this technique has proved to be very suitable for medium sized structures, "because it can be used to design

structures with pylons in proportion to the bridge," points out Erik Mellier. This special feature also opens up prospects for large structures, at a time, more so than ever, when we're looking to integrate structures into their environment. Yet in a context in which service life is the flavour of the day, the major benefit of this technique over the systems of competitors, which are still based on cement grout injections, is that it can offer the same durability and fatigue and weather resistance properties as those of stay cables used on large structures. ■



# IRELAND: BREAKTHROUGH IN A RAPIDLY DEVELOPING COUNTRY

With a presence in Ireland since 1981, the Group has seen the country's economy take off and has expanded its business on the basis of the competitiveness of its Reinforced Earth solutions and, more recently, its concrete floor prestressing expertise.

## REINFORCED EARTH COMPANY IRELAND

"Today, we are problem solvers." Martin Grace, Managing Director of the country's Reinforced Earth subsidiary, uses the term deliberately to sum up the positioning of Reinforced Earth Company Ireland, which offers its customers "efficient, less costly alternatives to the conventional methods of constructing structures such as slip roads or bridge abutments." The subsidiary has spared no effort in cultivating this image. Founded in 1981, near Naas in the suburbs of Dublin, from the outset the company was entrusted to Martin Grace, a geotechnical engineer, who took on its management and commercial

leadership. "The situation in Ireland was quite difficult at the time," he recalls, "and the subsidiary maintained a turnover of 1 million from 1981 to 1998, with around ten projects per year that I had to monitor by myself." During that time, all of the structural design was carried out by Reinforced Earth in England. A number of modestly proportioned but out of the ordinary structures due to their innovative nature, such as the Granny Railway arch bridge strengthened using TechSpan arches in 1994, contributed to the creation of the image sought by the company as a "problem solver". "With that project," emphasises Martin Grace proudly, "we demonstrated our inventiveness and efficiency,



From left to right: Martin Grace, General Manager of Reinforced Earth, Feargal Cleary, General Manager of Freyssinet.



1. The Elysian complex project used a total of 33,000 m<sup>2</sup> of prestressed floors, using 300 tonnes of steel, and deployed a team of 12.
2. The structure across the Blackwater Valley is fitted with two 24 m rows of Multiflex expansion joints.
3. In Sandyford, Freyssinet will have been involved in the floor prestressing of the McCambridge office building, using 90 tonnes of steel, from October 2007 to early February 2008.
4. Freyssinet's first project in the country, in 2006, involved the installation of the floor prestressing of the Carrickmines building in the suburbs of Dublin.
5. Reinforced Earth is involved in the construction of the abutments for some twenty structures on the M7 motorway (Dublin-Cork).

because the solution that we put forward also turned out to be very advantageous from an economic point of view."

Since 1998, as the country's economy has taken off, demand has increased and ambitious infrastructure projects have been completed under PPP (Public Private Partnership) contracts. This new method of awarding contracts has changed the subsidiary's business approach, as it has had to work upstream with general contractors. "Previously, we were in contact with the design offices in the qualification phase, and the contractors subsequently received orders to use such and such a method." But customers were gradually won over by Reinforced Earth due to its flexibility, remarkable mechanical

properties and the savings it allows for compared with conventional abutment or slip road solutions. With business growing, Martin Grace took on a designer from the English subsidiary in 2001 and has just recently recruited an operations manager. Although 80 to 90% of the subsidiary's work currently relates to road works, for which it designs between 30 and 40 structures per year, Reinforced Earth has increased its turnover to 5 million. The rest of its business is split between construction, industry, facilities such as water treatment plants, and even stadiums such as Newbridge, the grandstand and back wall of which were built using Reinforced Earth in 2006.

With its small team and several



3



4



5

projects underway, including new railway crossing structures, Reinforced Earth is continuing to play on synergies and draws on the experience of the English, Dutch, South African and Australian subsidiaries. Recent significant projects include the Reinforced Earth construction of an overpass slip road near Cork airport (7,500 m<sup>2</sup> with architectural facing panels), the biggest project Martin Grace has overseen in the country; the construction, which is still in progress, of the abutments for some twenty structures on the M7 motorway (Dublin – Cork); and the commencement of a structure for a 250 m railway bridge over the M7, on which a 3,500 m<sup>2</sup> wall will be built. There has been no shortage of projects using TechSpan arches

with several remarkable contracts, such as one for the Bloomfield Interchange bridge, which was awarded the 1999 Construction Excellence Award by the Construction Industry Federation in the Specialist Category, as well as for an impressive 20 m span, 100 m long arch for the Limerick southern ring road.

### FREYSSINET IRELAND

Founded in 2006, this young subsidiary has already completed some impressive projects. “Freyssinet had previously worked in Ireland, but didn’t have an office there,” says Feargal Cleary, Managing Director of Freyssinet Ireland. Fresh from Hong Kong, Cleary quickly had to form a team and recruit a site manager and three semi-skilled workers to

install the floor prestressing in the Carrickmine building in the suburbs of Dublin. Since then, the Irish subsidiary has successively completed several projects of the same type, which represent its principal business. “We are starting to develop in the field of bearings and expansion joints,” says Feargal Cleary, pointing out that some of the structures on the new M7 motorway between Dublin and Cork are fitted with elastomeric and mechanical bearings. As at Reinforced Earth, the Freyssinet Ireland team is fairly small, but it cooperates significantly with Freyssinet Ltd in England, which provides it with support in the field of prestressed floors in particular. “We have to convince architects, design offices and customers in Ireland of the

benefits of the technique,” emphasises Feargal Cleary, “and Freyssinet Ltd, which is an expert in the field, gives us valuable support.” This collaboration is bearing fruit, as this year Freyssinet Ireland is involved in the construction of four buildings, two of which are on a grand scale: the McCambridge office building in Sandyford (seven floors, 90 t of prestressing steel) and the multi-purpose complex The Elysian, for which the company has deployed a team of 12 for the urgent installation of 33,000 m<sup>2</sup> of prestressed floors (300 t of steel).

Although the synergies with other Group companies are mainly developing on the construction side, Freyssinet Ireland recently called upon the expertise of the Group’s Vélizy Technical Department (France) in relation to reinforcement work at the University of Cork using carbon fibre fabric. This small project enabled the company to demonstrate its expertise in the area.

Two years after opening, the Irish subsidiary already has seven engineers, two site managers and eight semi-skilled workers; it operates nationwide and has a turnover of 3 million, compared with 1 million in its first year. ■

# MENARD VACUUM: the force of the vacuum

In just twenty years, the Menard Vacuum process developed by Jean-Marie Cognon, the founder of Ménard, has been used to treat more than one million square metres of soft compressible soils in Europe, the Middle East, Asia and now Australia (see page 28).

To consolidate soft compressible saturated soil, the traditional preloading technique consists of loading the ground with imported fill. The weight of this fill compacts the soil where water is extracted like a sponge. Drawback of the method; it requires a long period of time. To speed up the process, an initial solution consists of installing vertical wick drains in the soil, which allow the water to drain off quicker. The time to consolidate soil with a thickness of 10 m can therefore be reduced from 30 years to 3 months, yet the risk of global embankment failure due to low shear strength of the soils has to be monitored and taken into account in the design of such a solution. "To eliminate this risk, we always had the idea of establishing a vacuum in the soil and using atmospheric pressure as a pre-

loading system," explains Jean-Marie Cognon. At the beginning of the 1980's, many companies explored the idea, carried out tests and some even published made-up thesis, made-up because no one had actually succeeded, in practice, to apply the vacuum principle in the field. Before developing an effective process, Jean-Marie Cognon himself tried and failed on three occasions: in 1980, 1983 and 1988. His last failure, however, allowed him to understand that in order to consolidate the ground not only did one have to create a vacuum in the soil, but also evacuate the water before it reached the waterproof membrane. Thus the Menard Vacuum principle with its horizontal draining system was born. The process immediately became a technical success ■



**1988** After the process patent was filed in 1988, the company took on its first job for a road development project in the bec d'Ambes (the Gironde), at the confluence of the Garonne and the Dordogne. After conducting, at its request, a pilot project monitored by the Laboratoire

Régional des Ponts et Chaussées (French regional structural engineering laboratory), the company was awarded the contract following a tender launched by the DDE and the Département and applied its process to successfully consolidate an area of 20,000 m<sup>2</sup> to a depth of 6 m.



**1991** In Lamentin (Martinique), a project started in 1991 to build an air-freight terminal on the mangrove (land containing eight times more water than soil). Very heavy loads were expected in the storage hangars of this facility. At the end of the tender process, the alternative using atmospheric consolidation of a 20,000 m<sup>2</sup> area proposed by Ménard was given preference

over the conventional and costly solution based on a structural floor supported by 25 m deep piles.



**1994** In the port of Lübeck (Germany), on the Baltic Sea, a dock unusable by modern ships was reclaimed using contaminated dredged spoils and transformed into a platform for container storage. 12 m of the platform were con-

solidated using the Menard Vacuum process. The area has also become a pollution containment facility because of the presence of a surrounding HDPE impermeable cut-off wall along the perimeter.

**1995** In South Korea, the alternative proposed by Ménard for the construction of the Kim Hae water treatment plant, on a site bordering the Nak Dong river, was chosen over a foundation solution using 40 m (creating a vacuum covering 3 million m<sup>3</sup> of soil) piles solution that was twice as expensive. Deployed over 80,000 m<sup>2</sup> to consolidate 40m of soft clays, the technique achieved a record compression of 5.30 m. Following this project, the company was awarded

four other atmospheric consolidation contracts in the country: the Jangyoo water treatment plant (1998) and two 295,000 and 55,000 m<sup>2</sup> container terminal platforms reclaimed from the sea in the port of Kwang Yang.



Before.



After.



**2001** In Hamburg (Germany), the Airbus A380 assembly site is built on 140 ha of land reclaimed from a dead branch of the Elbe consisting of muddy deposits. To isolate

the northern zone where the work had to start in emergency, Ménard used atmospheric consolidation to create a 135,000 m<sup>2</sup> dike to a height of + 9 (8.50 m above mud level).



**1997** An alternate of the Menard Vacuum process, a venting system based on the use of drains and pumps and a waterproof membrane was installed under the Stade De France (St-Denis, France) to treat the gas fumes coming from

the contamination of the ground. After working permanently for the first two years of operation of the stadium and allowing the extraction of some 500 tonnes of fuel, the system is now in operation for just one week per quarter.



**2005** In southern Vietnam, the Cai Mau power station was to be built on 161 ha on the banks of the Cai Tau river. 240,000 m<sup>2</sup> of soil required consolidation, 90,000 m<sup>2</sup> of which had to be completed in under one year. To meet this deadline, Ménard divided the site into

six zones and applied the Menard Vacuum process on the first 90,000 m<sup>2</sup>. 27 pumps were installed and 465,000 m<sup>3</sup> of water extracted. 1.50 m above its original natural height, the consolidated soil had a bearing capacity of 10 tonne/m<sup>2</sup>.

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