

Soils & Structures

THE FREYSSINET GROUP MAGAZINE

FOCUS LNG: CRYOGENIC PRESTRESSING
DERIVED FROM THE NUCLEAR INDUSTRY

REALIZATIONS KANNE BRIDGE (BELGIUM):
A FIRST FOR COHESTRAND

HISTORY 1930-2005: THE RISE OF LIFTING

PRESTRESSED CONCRETE FLOORS A Far-Reaching Technique

No. 222 Second half of 2005



Reinforced Earth



SOLTRAITEMENT

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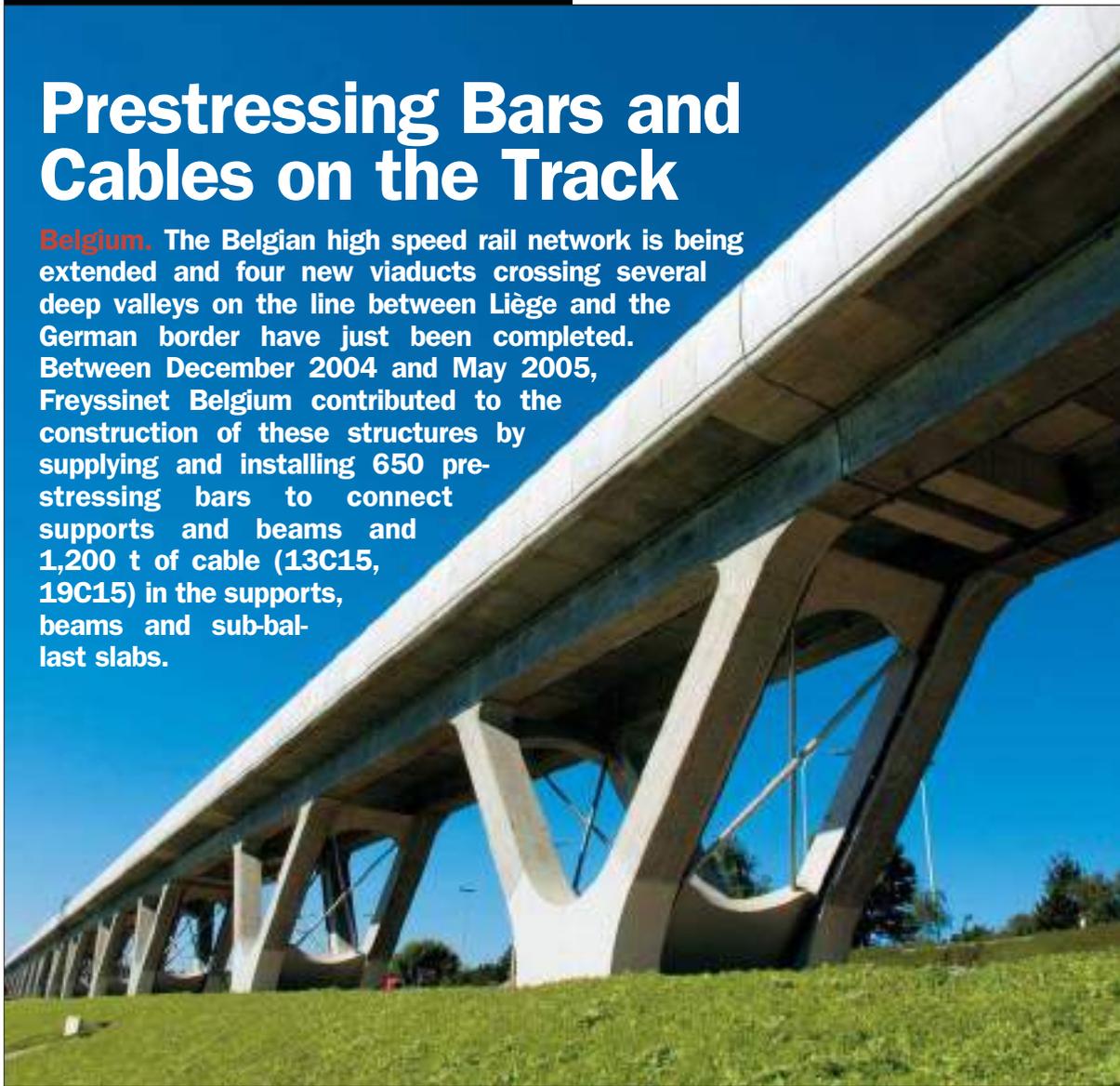
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Prestressing Bars and Cables on the Track

Belgium. The Belgian high speed rail network is being extended and four new viaducts crossing several deep valleys on the line between Liège and the German border have just been completed. Between December 2004 and May 2005, Freyssinet Belgium contributed to the construction of these structures by supplying and installing 650 prestressing bars to connect supports and beams and 1,200 t of cable (13C15, 19C15) in the supports, beams and sub-ballast slabs.



Know-how on the Agenda

Turkey. On 31 May and 1 June last, under the respective chairmanship of Professor Erhan Karaesman and Emre Aykar, Managing Director of Yapi Merkezi, Freyssinet International and C°. and Freysas, the Group's Turkish subsidiary, organized two conferences in Ankara and Istanbul on long span bridge design and associated construction methods. Around 200 people attended presentations by Michel Virlogeux, Benoît Lecinq and Jérôme Stubler at the conferences.



Natural Panels at the Zoo



Spain. The architects of the new Valencia Zoo chose Reinforced Earth for the structures marking the boundaries of the park's different areas. Tierra Armada SA is currently building 13,600 m² of separating walls for the project. These will be clad with imitation stone panels decorated with themes inspired by the jungle.



Third TechSpan Arch Structure

United Arab Emirates. 150 km west of Doha on the Umm Bab-Salwa road, Reinforced Earth is working on the third site to use TechSpan prefabricated arches in Qatar. They are building a structure using 8 elements, each with an opening of 13 metres and a length of 34 metres. At each outlet the tunnel walls will be given a Freyssisol facing.

Success for CMCs

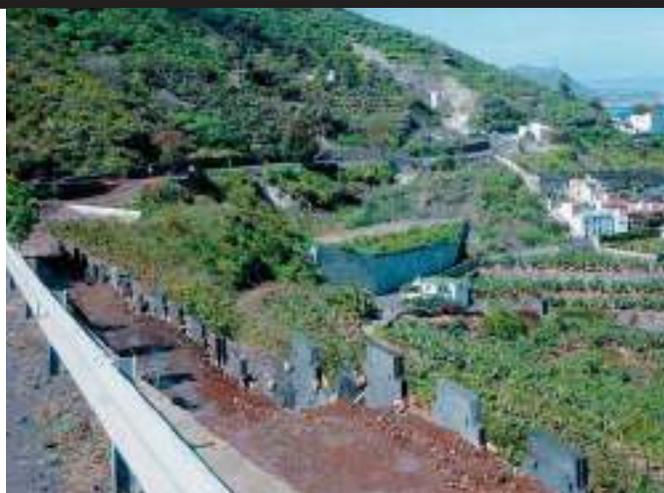
United-States. With its proposal for a controlled modulus column (CMC) soil treatment solution, DGI-Menard (Freyssinet) was awarded the contract for works prior to the construction of a service station at Monongahela in Pennsylvania, which it carried out during the summer. Following completion of the work, during which 135 CMCs were installed, the company won a new contract of the same type in the Washington area.



Landscape Integration

Spain. On the island of Tenerife in the Canaries, two 5,580 m² and 1,312 m² tiered retaining walls, designed by Tierra Armada (Freyssinet), were built during

widening works on the TF-142 coastal road between El Guincho and Icod. Particular architectural care was taken over the facing panels for the two structures in order to ensure perfect integration into the environment.



External Prestressing

Russia. Since the beginning of June, Freyssinet has been supplying and installing external prestressing for the steel roof of a new ice rink in Kolomna, near Moscow. The saddle roof is 250 m long and 150 m wide.

3,600 tonnes of Prestressing

United Arab Emirates. Freyssinet Gulf has just won the contract to supply and install the prestressing (3,600 t) for the Ras Al Khor Bridge.

Connecting the mainland part of Dubai to an 11-kilometre long peninsula separated from it by a sea inlet, the structure comprises two decks providing six new traffic lanes and is made up of 8 spans, each with a length of 60 m.

Supply and Support

Morocco. Since February 2005, Freyssinet has been providing technical support on the new Casablanca to El-Jadida motorway to Moroccan company SGTm, which is building the bridge over the Oum er-Rebia. Comprising two parallel 500 m long decks made up of segments cast in situ, this cantilevered structure will carry four lanes of traffic. Freyssinet is supervising the construction work and has supplied two pairs of mobile rigs as well as the prestressing and works equipment.





Prestressing for Four Gas Storage Tanks

Iran. With an area of over 1,300 km², the South Pars field in the Persian Gulf is one of the world's largest natural gas deposits and its development means that ground installations need to be constructed regularly. Four storage tanks are currently being built, two with a volume of 55,000 m³ for propane storage and two with a volume of 45,000 m³ for butane. Freyssinet has supplied and installed all of the prestressing for these four structures (900 t) and more than 1,100 anchors.

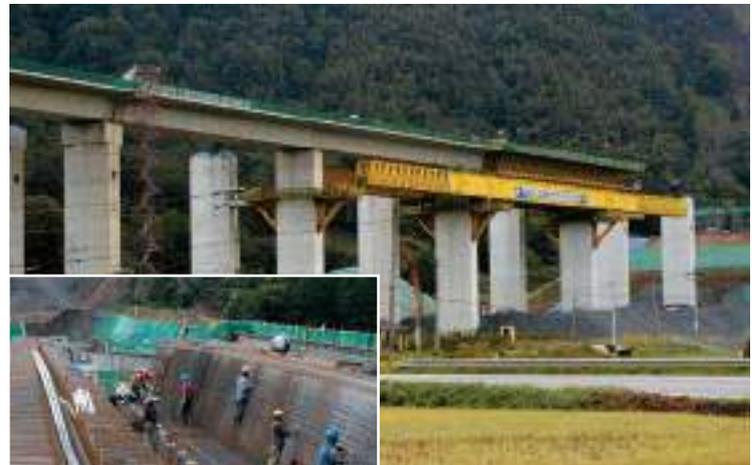
FIB Symposium 2005

Hungary. Freyssinet and Pannon Freyssinet, the Group's Hungarian subsidiary, took part together in the *FIB* (federation internationale du béton - international federation for structural concrete) symposium held between 23 and 25 May in Budapest on the theme "Keep concrete attractive". As well as presenting its most recent worldwide achievements with special emphasis on those in Eastern Europe, the Group also took part in the conference with a noteworthy presentation by Benoît Lecinq on the Kanne Suspension Bridge in Belgium and the use of the Cohstrand strand.

Reinforced Earth on the Rome Ring Road

Italy. Having carried out the design work, Terra Armata is supplying the materials for several retaining walls for Rome's new ring road.

Measuring up to 14 m in height and 350 m in length, these MSE structures use two types of facing, namely conventional TerraClass cruciform concrete panels and TerraTrel welded mesh.

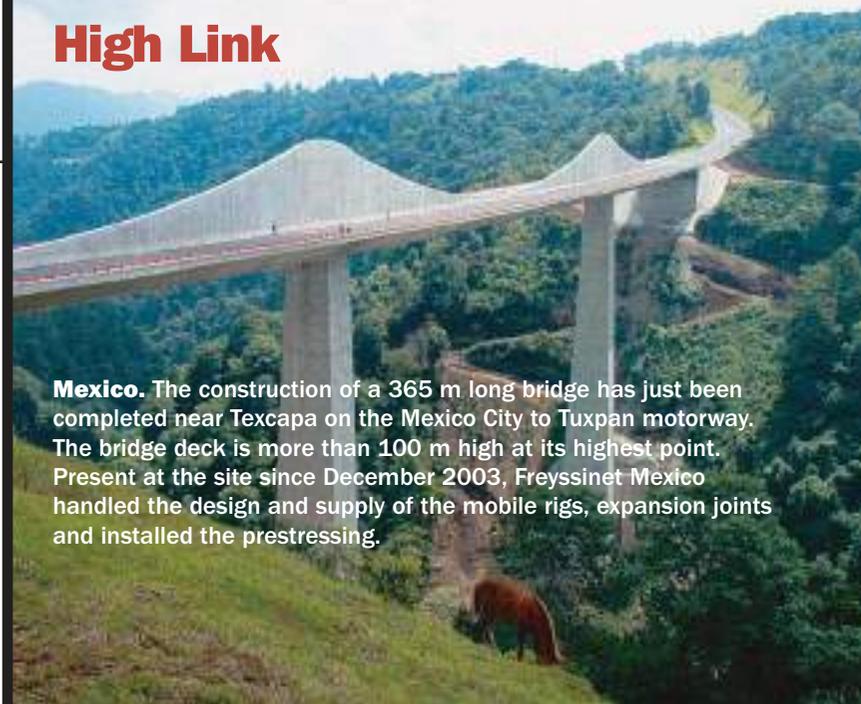


50 m-Long Span

South Korea. Equipped with an MSS (movable scaffolding system) type self-launching truss, Freyssinet Korea is building both parallel decks of the

Hwaebuk 1 (520 x 12.15 m) and Hwaebuk 2 (300 x 12.15 m) motorway bridges between the localities of Chungwon-gun and Chungcheongbuk-do in the east of the country. The 60 m-long truss, which weighs 200 t, allows for each 50 m-long prestressed span to be completed in just 35 days.

High Link



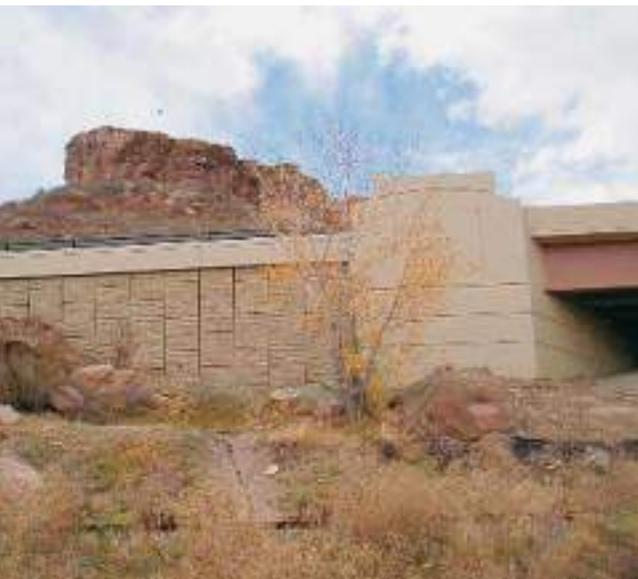
Mexico. The construction of a 365 m long bridge has just been completed near Texcapa on the Mexico City to Tuxpan motorway. The bridge deck is more than 100 m high at its highest point. Present at the site since December 2003, Freyssinet Mexico handled the design and supply of the mobile rigs, expansion joints and installed the prestressing.

Inspired Facing



United States. The town of Castle Rock (Colorado) has just seen the completion of a road bridge crossing a railway track and a road intersection.

Designed by the municipal authorities and consulting engineers in consultation with the inhabitants, the structure includes facing inspired by the rock pattern typical of the region so that it blends into its environment. Reinforced Earth was given the job of designing and supplying materials for the retaining walls. The company reproduced the pattern on the facing panels in six different variations. These were then arranged at random over the entire structure in order to reproduce the irregular appearance of the rock as closely as possible.



750 t of Prestressing for a Viaduct

Hungary. In March 2006, Pannon Freyssinet, the Group's Hungarian subsidiary, will begin the installation of 750 t of internal prestressing for the Köröshegy viaduct. Located between Zamardi and Balatonszaszo, 120 km south west of Budapest, this new structure, which will carry the M7 motorway, is 1,800 m long and has 17 spans, the highest of which are 88 m at their highest points.

On the Moraca River

Montenegro. After commencing in May 2005, the installation of the stay cables on the Millennium Bridge, near Podgorica, was completed at the beginning of the summer and the structure was inaugurated on 13 July last. Freyssinet supplied the stay cables (300 t) for the structure, which crosses the Moraca River with a span of 173 m and supervised their installation by the general contractor as part of its role as technical support provider.



Mecatiss joins Freyssinet

France. Following the integration of Salvarem at the beginning of 2005, the takeover of Mecatiss on 6 September 2005 strengthens the Group's capabilities in the nuclear field.

Headed by Bernard Marquez and attached to the Freyssinet Structures Division, Mecatiss designs, manufactures and implements fire barrier, leakage protection and radiation protection systems meeting the requirements of the nuclear, petrochemical and shipbuilding industries and airports and public buildings. Equipped with an integrated test laboratory, the company pursues an active R&D programme and studies all new techniques and applications relating to textiles, silicon elastomers, resins and mineral fibres to meet the specific needs of its customers.

A Ready-to-Assemble Quay

South Korea. The Pusan port authorities have chosen a design favouring protection for the installation of a new quay in an area of the port battered by the swell. The structure (350 x 50 m) has been entrusted to general contractor Posco E&C Corp., and makes heavy use of prefabricated elements, which have been subcontracted to Freyssinet Korea. To produce the structure's 100 prestressed concrete caissons, 800 slabs (8 x 4 m) and 500 vertical panels (22 x 1.6 m), the company will pour a total of 15,000 m³ of high-performance concrete and install 729 t of prestressed steel.

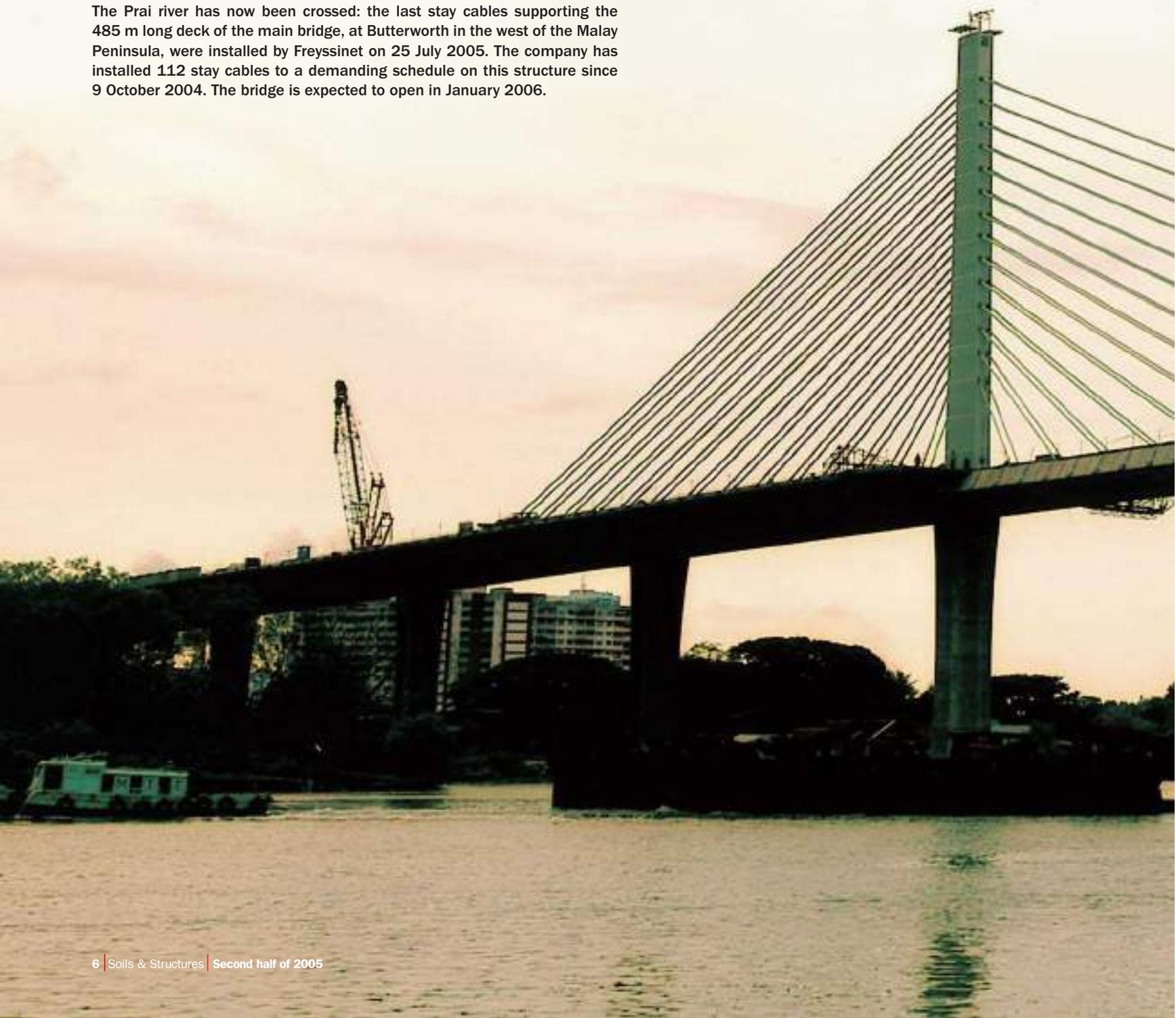


Cable-stayed roofing

Egypt. To accommodate the finals of the next African Football Cup of Nations, which will take place in Egypt in January and February 2006, Alexandria has started work on an 80,000 seat stadium. The suspension for the roof that will partly top the structure consists of 18 horizontal and 19 vertical stay cables supplied and installed by Freyssinet.

Sungai Prai, Ready for Service

The Prai river has now been crossed: the last stay cables supporting the 485 m long deck of the main bridge, at Butterworth in the west of the Malay Peninsula, were installed by Freyssinet on 25 July 2005. The company has installed 112 stay cables to a demanding schedule on this structure since 9 October 2004. The bridge is expected to open in January 2006.





JÉRÔME STUBLER, DEPUTY GENERAL MANAGER

LNG: Cryogenic Prestressing Derived from the Nuclear Industry



Having played a role in equipping the containment vaults of nuclear power stations all over the world for more than 30 years, Freyssinet has worked tirelessly to perfect its prestressing system. Today, its quality and performance make it the solution of excellence for the construction of liquefied natural gas (LNG) storage tanks. Jérôme Stubler, Deputy General Manager and Structure Division Director, explains.

Soils & Structures. - As a preferred player in the development of France's nuclear power stations, for which it supplied and installed all the prestressing, Freyssinet is now positioning this technology on the market for liquefied natural gas (LNG) storage tanks. What exactly does that involve?

Jérôme Stubler. -Just like the structure that houses a nuclear reactor, the concrete shell of a liquefied natural gas storage tank is a containment vessel. They are both circular vessels designed to contain the

internal pressure that could be caused by an accident, as well as for normal operation for certain storage tanks with internal metal liners that rest on the concrete shell. In both cases, the quality of the prestressing is the decisive element in the structure's performance and durability. This quality, which has established Freyssinet in the field of nuclear power stations, is also the mark of our capabilities in the LNG market. Over the last three years it has been illustrated on numerous storage tank construction sites all over the world (see p. 9).

What makes Freyssinet's nuclear prestressing different?

Over the last 30 years the company has been associated with the construction of all of the containment vaults for power stations in France and a very large number of those built in prestressed concrete all over the world. Today, the Company is present in India and China at conventional power station sites as well as in Finland, where the first EPR (European Pressure Reactor), due to take over from the plants currently in operation, is being built

at Olkiluoto (see also p. 20). This success, originally linked to EDF's requirements, which were decisive in the development of high-performance models, is also a result of internal requirements and has been illustrated over time by continuous progress in the fields of products, research and implementation. Regarding products specially developed for nuclear power stations, one has to mention the 55C15 anchor, the most powerful unit in existence, the ducting systems under ductile

rigid tubes, which provide an additional guarantee of the impermeability of structures, and special thixotropic grouts ("Thixogel") that allow for totally bleed-free injection, thus giving optimal and longer-lasting corrosion protection. In parallel, new implementation procedures have been developed. These include equal tension jacks, which make it possible to obtain the same tension in every strand and reduce creep, which is another additional guarantee of longevity. But Freyssinet's nuclear prestressing service is more than just a product supply: the company develops detailed execution methods and provides site owners with dedicated teams having experience of implementation and the very rigorous quality assurance procedures peculiar to structures of this type.

Costa Azul, a Project in Mexico with VINCI Construction Grands Projets

On 4 July 2005, as a subcontractor of VINCI Construction Grands Projets, Freyssinet was awarded the contract for the supply and implementation of the prestressing for two liquid natural gas storage tanks in Costa Azul, south of Tijuana (Lower California), Mexico, a region with high levels of seismic activity. These structures will be built by VINCI Construction Major Projects for Sempra, an American gas sales company.

Each with a capacity of 160,000 m³, these two storage tanks will require the installation of 920 t of prestressing in the form of horizontal prestressing comprising 19T15 cables and U-shaped vertical prestressing using 13T15 cables. The site was supplied with the first prestressing elements and materials in September 2005 for implementation lasting from the end of 2006 to spring 2007.

Idku (Egypt).



Sakhalin (Russia).



South Pars (Iran).



Altamira (Mexico).



So it's a tried and tested model that Freyssinet is now using as a basis for developing its position in the LNG market?

The similarity of the structures and the importance of the safety and durability of these structures form the basis of the approach, which aims above all to provide the appropriate technical response, guaranteeing quality. LNG storage tanks have a special feature which is the very low temperature, - 160°C, at which the gas must be kept in order for it to remain in a liquid state. As this temperature also affects the structure, Freyssinet has worked on a "cryogenic"

prestressing, i.e. one that retains its ductility and does not become embrittled despite the temperature conditions. The solutions proposed for the two storage tanks currently being built at Chengdu in China have successfully met the challenge of cryogenic resistance tests. In parallel with this type of technical response, and on the nuclear model, Freyssinet offers its customers an organization that gives them access to all of the experience of Freyssinet's network in both research and operations.

So all in all, the offering is customized to meet the

specialized requirements of our customers?

Faced with rising oil prices and the prospect of resources running out, gas, which also has the benefit of a cleaner image, is becoming an attractive energy source and the number of development projects is increasing. In 2003, there were over 100 exporting and receiving terminals due to be built worldwide by 2020, representing an investment of approximately 3 billion euros. More recently, the Chinese authorities have announced their desire to diversify their energy supply sources and increase the proportion of natural gas to 7 or 8%.

Clients, sites, projects

In 2004, Freyssinet supplied and installed 700 t of prestressing on the two 140,000 m³ storage tanks at Idku in Egypt, implemented with VINCI Construction Grands Projets. Eleven storage tanks are also under construction:

- Sakhalin (Russia): Two 130,000 m³ storage tanks (750 t of prestressing);
- Fos-Cavaou (France): Three 103,300 m³ storage tanks (1,400 t of prestressing);
- South Pars (Iran): Two 55,000 m³ LPG (*liquefied petroleum gas*) storage tanks and two 40,000m³ LBG (*liquefied butane gas*) storage tanks (1,000 t of prestressing);
- Chengdu (China): Two 160,000 m³ storage tanks (1,230 t of prestressing).

Several others are being planned in Mexico (see box) as well as UK, Spain, Belgium and Nigeria.

In parallel, the last few years have seen a huge increase in the price of steel, making all-metal storage tanks less competitive.

In this very buoyant context, Freyssinet's LNG prestressing service thus has both technical and economic advantages. ■

A FAR-REACHING TECHN

Market necessities, force of habit and the culture of the sector have favoured the growth of floor prestressing in many countries, but have not allowed it to develop in France. This situation could change with the introduction of new regulations in 2006 and thanks to concerted efforts at Freyssinet.



THE MALAYSIA TELECOM TOWER in Kuala Lumpur (Malaysia): 76 floors, 230,000 m² (1997).

MORE THAN HALF A CENTURY LATER the opposition encountered to prestressed floors in France is a reminder at Freyssinet of the opposition Eugène Freyssinet had to overcome at the time of his invention. Of course, this time it is not a question of bringing about acceptance of an idea or a new material, but of changing design and implementation habits in order to allow the technique to extend its field of application beyond the few cases where it is absolutely necessary. "Luckily there's no shortage of references",

comments Fernand De Melo, Freyssinet's Technical Director in France who, having worked abroad for a long time naturally mentions Australia, South East Asia, Singapore and Hong Kong, regions where the combination of rapid urban growth and a lack of space have favoured the technique. "But," he emphasizes, "much closer to home, Great Britain is a key example, if not a model." (see page 13). "On the one hand, the advantages of the technique are glaringly obvious," continues the Technical Director, inviting us to compare two photos of car parks, one conventional, with a forest of pillars, the other astonishingly spacious and clearly better able to facilitate traffic movements and parking. "In fact," explains Fernand De Melo, "the advantage of prestressing, which is found in civil engineering and the building trade with this type of floor, can be summed up in two terms: increase of span, which in this case can be up to 15 m as opposed to 7 to 8 m, and the weight reduction of structures (floor thicknesses can be reduced from 40 to 20 or 25 cm)". This brings a whole range of advantages such as the reduction of expansion joints and the cost of

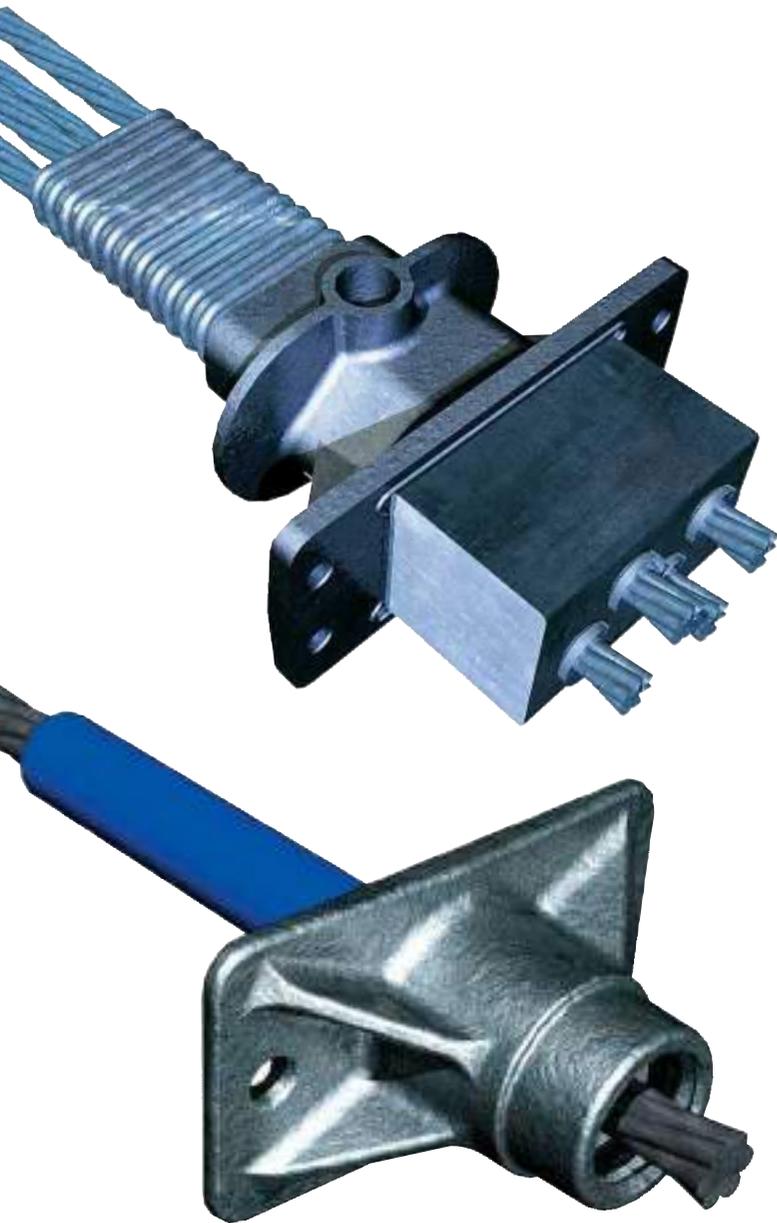
BONDED PRESTRESSING is made up of strands enclosed in a sheath injected with a rigid product (such as cement grout).



UN-BONDED PRESTRESSING is made up of sheathed greased strands directly installed within the floor slab or inserted into sheaths injected with a flexible product (wax, grease, etc.).



IQUE



maintaining them, etc. The benefits of the technique in terms of applications follow on very logically from this basic data.

Vast Platforms

For architects and project managers, this makes it possible to “save space” with vast column free platforms, which are very

favourable for creating open spaces that are easy to fit out and are highly suitable for office buildings, as well as facilities such as shopping centres, airports and car parks. For building owners, this space saving also translates very firmly into extra square metres of space, particularly in the case of very tall buildings, where one level

A Full Range of Solutions

TWO TECHNIQUES...

There are two types of technique for prestressed floors: prestressing by bonded post-tensioning, in which the bare strands in a smooth or ribbed sheath are injected with cement grout after being tensioned and un-bonded prestressing, which uses strands remaining free inside a sheath, where they are protected from corrosion by a grease.

Un-bonded prestressing is often more economical for floors not subjected to excessive loads. It is less advantageous if a high level of prestressing is needed (premises subjected to significant loads such as archive buildings) or if there is a risk that floor openings will be made after pouring, since un-bonded prestressing requires the recreation of anchors after the tendons are cut. In certain cases, the two techniques are combined: bonded prestressing in beams and un-bonded prestressing in slabs.

...TWO SORTS OF STRAND, SEVERAL TYPES OF ANCHOR

The two diameters of strand used are 15.70 mm (T15 strand) and 13 mm (T13). Depending on the diameter and the number of strands they receive (1, 3, 4, 5), the anchors are given code names that are easy to decipher: 1E15 (1 strand of 15), 3E13, 3E15, 4E13, 4E15, etc.

IMPLEMENTATIONS

Unlike subcontract packages that do not interfere with the ‘critical path’ of the project, floor prestressing involves cooperation between the main structure contractor, who frequently carries out the main work (formwork, passive reinforcement and concrete placement), with the Freyssinet teams responsible for installing, inspecting and stressing the post-tensioning materials. Complying with the positioning tolerances within the slab thickness is critical to the execution phase. It has led Austress Freyssinet to develop a range of “chairs” making it possible to guarantee the positioning of the sheaths to a close tolerance. These are now also used in Great Britain.

can be gained every 20 to 25 floors. Finally, structural simplification equals savings on materials and a reduction in overall cost – advantages that companies can’t ignore when preparing their responses to invitations to tender. Freyssinet estimates that savings of the order of 15 to 20% can be made. Paradoxically, since its appearance in the 1980’s as an adaptation of the technique used for civil engineering structures, floor prestressing has never really taken off in France. “Prestressing is not part of the building construction culture in

France,” Fernand De Melo believes. “On the one hand, this is because construction design offices are not used to designing using the technique, and on the other hand it is because general contractors that could turn to specialist design firms are reluctant to do so for fear of losing control.” “It also suffers from a special technical status that limits it to such cases where there are large spans, unusually heavy live loads and to what are known as ‘transfer floors’, where it represents the necessary alternative to reinforced concrete,” explains ▶▶



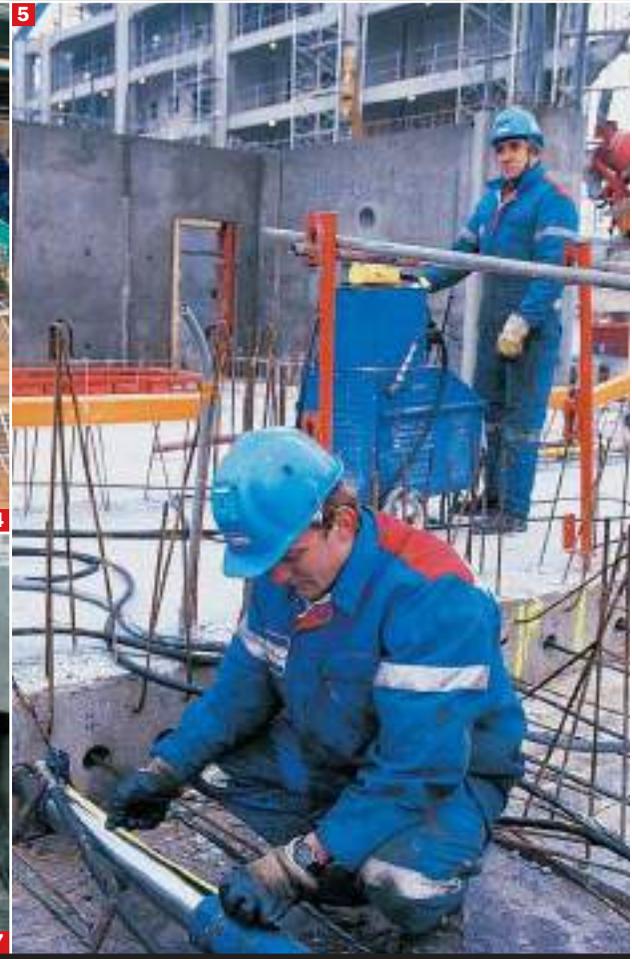
1 2



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4



5



6



7

►► Christian Lacroix, Freyssinet Regional Director for Île-de-France. Regulations have also been a hindrance. The BPEL (béton précontraint aux états limites / prestressed concrete at limit states) calculation method used as a reference by the technical inspection services is applicable to civil engi-

neering structures but has been shown to be unfavourable for prestressed concrete floors, where it leads to an increase in passive steel quantities and consequently the cost price. In this apparently static context an important change will nevertheless occur as from 2006 with the intro-

duction of the Eurocode. More favourable to the technique, this regulation drafted within the European framework could restart a process by allowing companies to use the services of design firms applying the new calculation method, enabling them to make their designed structures more

innovative and competitive. "The Freyssinet technical department dedicated to prestressed floors consists of a manager at each of Freyssinet France's regional offices and is responsible for ensuring that expertise is pooled and that we function as a network," says Fernand De Melo, "and we

For bonded prestressing, the strands are delivered to site on reels (weighing around 3 tonnes). They are unwound, cut to length and threaded into the sheaths before concreting (2).

For un-bonded prestressing, the cables (1) are usually delivered prefabricated (fitted with anchors at the ends). They are installed directly in the reinforcements (3), on the chairs placed on the formwork.

The cables can be tensioned using a light monostrand jack, generally three days after concreting, thus allowing for the removal of the formwork (4-7).

The Technique Saves Space and Reduces the Overall Cost of Projects.

“Belgium: a 25-year lead, but the same obstacles”

Over the last ten years, Freyssinet Belgium's achievements in Belgium and Luxembourg must represent an average of 30,000 m² of prestressed floors per year," estimates Edouard Henrard, Sales Director of Freyssinet Belgium. This figure simply reflects the adaptation of companies to their markets: in France, the development of the motorways generated a good deal of activity until 1985; this was not the case in Belgium, which is a small country where work of this type was completed in 1970. Necessity knowing no law, it is now over 25 years since we turned to pre-

stressed floors and established contacts with very active design firms. Our first projects were office buildings in Belgium and Luxembourg (offices for Fortis Banque, Brussels National Airport, the Social and Educational Institute and hospitals, car parks and shopping centres, open space offices, etc.). For all that, we encountered the same obstacles as in France at all levels of the process. In France there is an additional handicap due to the considerable development of prefabrication and the market share of that technique in car parks and short-span buildings.”

Great Britain: regulations change everything

Over the last 20 years, the annual production volume of prestressed floors in Britain is estimated to have increased from less than 50,000 m² to 1.3 million m². At the end of a 2005 business year with a particularly large number of projects completed in Britain and Ireland, Patrick Nagle, Managing Director of British subsidiary Freyssinet Ltd., and Paul Bottomley, Technical and Sales Director, answered three questions for *Soils & Structures*.

How do you explain the success of prestressed floors in Great Britain? Is it a recent phenomenon?

PATRICK NAGLE. – 10 years ago we had to canvass architects and consulting engineers, as it seems you have to do in France with your partners, in order to convince them of the advantages of floor prestressing. Those days are all but gone and since the end of the 1990s, the trend has changed and so have mentalities. Today, people approach us to cost solutions that incorporate prestressing right from the design stage. Cases come to us in the form of preliminary designs (slab configuration, thickness, loads) to be finalized, which is what our design office does.

This success is the fruit of the long-term work undertaken by Freyssinet Ltd. and other companies to change mentalities and culture in the United Kingdom - and it took some time. Another explanation, linked to a more recent phenomenon, is that the increase in labour costs and steel prices has also increased the attraction of prestressing. I would also add the time saved on the site compared with a reinforced concrete solution, which accordingly represents a financial saving for the general contractor and the space saving offered by prestressed floors. In fact, within the same “shell”, the designer can plan for additional floors. Finally, I would say that the success has been

boosted by the increase in the average height of buildings. In 2004 in Manchester, Freyssinet Ltd made 31,350 m² of prestressed floors for a 47-storey building, which is more than 170 m high and will house the Deansgate Hilton Hotel.

Are British regulations favourable to this technique?

PAUL BOTTOMLEY. – The obligation you have in France to use a minimum amount of passive steel in defined locations does not exist to the same extent in the UK. Here, the rules for the design of prestressed floors are defined by British Standard BS8110, supplemented by technical report no. 43 published by the Concrete Society. These recommendations are in fact very favourable to the technique, since they make it possible to reduce the conventional reinforcement to a minimum. In practice we can often remove all the passive steel in the bottom mat and most of it in the top. This is completely ▶▶

hope to be able to rely on Belgium, where Edouard Henrard has been working with a design firm for some time.” Before the new regulations come into force, this department will also benefit from the calculation expertise of two specialist engineers. In this field, support for the French team will come from across the Channel, where the British work according to a regulation (the British Standard) similar to the Eurocode and have agreed to provide advice and support in the selection and use of calculation software.



- 1. 72,000m² of prestressed slabs were produced for the Neder-over-Heembeek water treatment plant in Vilvoorde (Belgium).
- 2. National Bank Tower in Abu Dhabi (United Arab Emirates).
- 3. In the heart of London (United Kingdom), the prestigious Esso Glen office complex has a total of 50,000m² of prestressed floors.
- 4. A car park without prestressed floors, with its forest of columns and cramped parking spaces.
- 5. The car park at Atatürk airport in Istanbul (Turkey), designed with prestressed slabs, has large open spaces.
- 6. Prestressing was used for the hemicycle at the European Parliament in Strasbourg (1998) to reduce the height of the structure (thinner floors), provide stability and earthquake-resistant monolithic behaviour, and optimise the spans between shells.
- 7. The prestressed slabs used for the new ExCel exhibition centre in London give the building a high load-bearing capacity.



“The Strength of Freyssinet Ltd. is its Considerable Expertise and its Design Office.”



► different from what is customary and permitted in France. As well as that, the strength of Freyssinet Ltd. in this field is its considerable expertise and its design office, which enable it to design and calculate prestressed floor solutions.

In practice, how is your work on sites organized, in particular with the contractor in charge of the main structure?

P. N. – Sometimes, particularly in Ireland, we are involved with the general contractor, but more often than not our customer is in fact the "frame" contractor who is responsible for the formwork, reinforcing and placing the concrete. We work with them to produce the slabs. Unlike in France, where small areas are worked on with daily rotations, we work on larger pour areas, sometimes greater than 1000 m² with a cycle time of 4 to 6 days. Our role consists of installing the prestressing elements, tensioning the strands and injecting the ducts with the cement grout. The technique has not disrupted the organization of sites as we are relatively independent in relation to the other operations. We are the ones who adapt, and that's why the main structure contractors use our services.

Emirates: a technique that meets a need

In the United Arab Emirates, floor prestressing has been in regular use since the 1990s. Khalil Doghri, Managing Director of Freyssinet Middle East in Dubai, and Khalid Rabadi, Building Prestressing Division Manager, explain why.

What are the most important facts about Freyssinet Middle East's floor prestressing business?

KHALIL DOGHRI. – The technique, which is limited to bonded prestressing, began in the region in the 1990s after being introduced by the Australians. Today it is widely used in the Emirates, especially in Dubai which is going through a building boom – the world's tallest tower is being built there. Floor prestressing is part of the offering of many companies, some of which are from Asia, Australia, India, etc., including one or two general contractors that have acquired the know-how for smaller projects.

How do you explain this success?

K. D. – Buildings with spans of more than 7 m are being suggested increasingly often by architects for their greater convenience in terms

of the use of space and layout. This is exactly the type of span permitted by our technique, which also brings many other advantages, such as reduced floor thickness, elimination of beams, reduction in building height, ease of installation for air conditioning equipment, etc. The technique is also attractive for main structure contractors as it allows them to build more quickly using less steel and at a lower cost. As far as the spread of the technique is concerned, we are in the opposite situation to the one in France, but for the same reason; force of habit, the culture of engineers and the way companies build have ensured the development of prestressing in the building floors.

How is your cooperation with the general contractors organized?

KHALID RABADI. – Upstream of proj-

ects, our design office studies the solutions to offer for the contractors and quantifies the savings that can be made. These optimized solutions represent 50 to 60% of the contracts we handle. Once the contractor is awarded the contract, we provide assistance with implementation and materials, such as cables, sheaths, anchors, etc. Our site superintendents supervise the general contractor's workers, who install the prestressing, but we are responsible for the work and are present at the time of pouring. Beyond the technical aspects we emphasize quality of service, which is an integral part of technical quality and the warranty given for the work. In practice, this assumes faultless organization so that the materials are supplied exactly when they are required. We also have to coordinate our involvement with the work on the main structure, which not all suppliers can do. We could doubtless improve our command of this service and our competitiveness by sharing our experiences more at a Group level. ■

STRUCTURES/KANNE BRIDGE

A First for Cohestrand

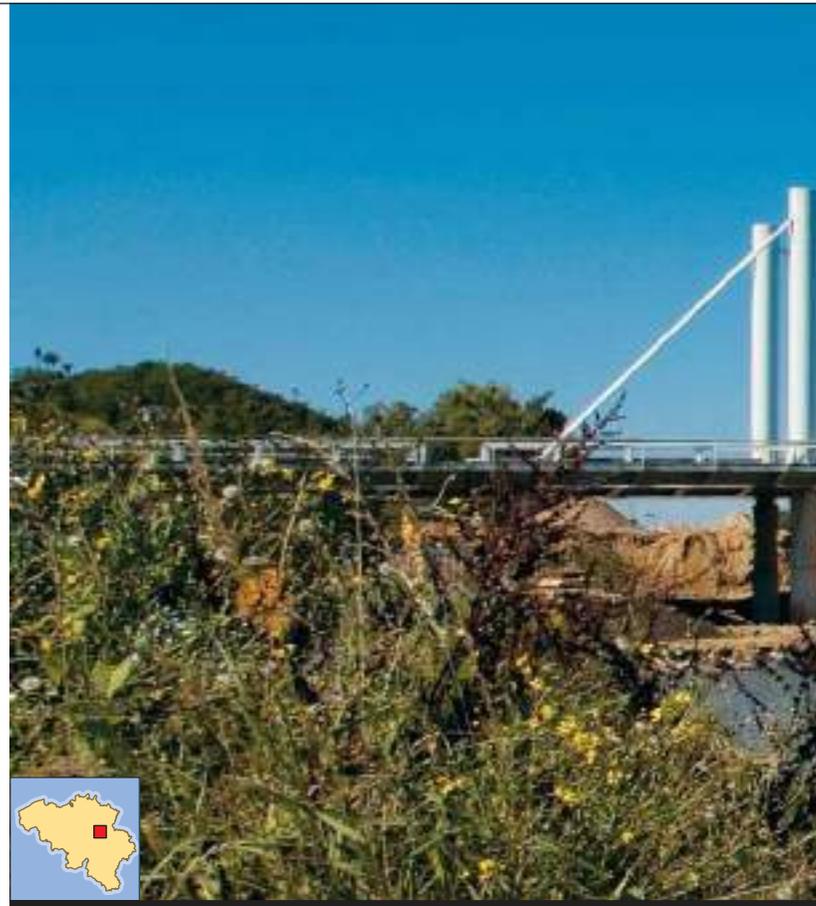
Specially developed by Freyssinet to meet the constraints of suspension bridge load-bearing cables, the Cohestrand strand has been implemented on an industrial scale for the first time on the Kanne Bridge in Belgium.

OPENED TO SHIPPING IN 1939 and 129 km long, the Albert Canal, which connects Antwerp to Liège, today carries more than one third of the traffic on Belgium's waterway network. However, in the province of Limburg in Flanders, a part of the canal is still not accessible to the 9,000 t pushed convoys, which have become the standard in Europe. Major enlargement works have therefore been started in order to modernize this strategic route. Close to the city of Kanne to the south-west of Maastricht (Netherlands), the canal enlargement has led to the replacement of the existing bowstring bridge by a new structure. "The suspension bridge solution was chosen for architectural reasons and to preserve a high river gauge without having to make access ramps that were too steep," says Claude Mortier, Director of Freyssinet Bel-

gium. This is the first structure of this type to be built in Belgium since the 1960s. The owner nevertheless drew special attention to the service life of the suspension cables, which had to be comparable to that of stay cables, which in particular meant guaranteeing the continuity of the anti-corrosion barrier through the collars."

Two 75-strand cables

Freyssinet's Cohestrand system was chosen to meet this requirement (see opposite). "This site is also the first implementation on an industrial scale on a suspension bridge," explains Benoît Lecinq, Technical Director of Freyssinet. "Until now, only one prototype bridge with a span of 88 m and main suspension cables with 7 strands had been built at Chartrouse in the Camargue on a private estate." This new metal bridge comprises a main span 96.20 m in length and two 14.80 m



lateral spans. Mixed steel/concrete structure access viaducts flank the bridge. The deck, which is 21 m wide, carries two lanes of road traffic located between the hanger positions and two tracks on the outside for cycles and pedestrians only.

On either side, the load-bearing cables, each consisting of 75 strands, are supported by cylindrical masts 25 m high (16 m above the deck).

A protective sheath

On each of the cables, 24 hangers spaced at 3.70 m bear the weight of the deck. Between the collars an external sheath in white HDPE specially designed to protect the strands against the effects of ultraviolet rays and mechanical stresses covers the load-bearing cable. "Each hanger consists of 5 x T15.7 monostrands also housed in an external sheath in white HDPE, and can be likened to a Freyssinet stay cable," adds Benoît Lecinq. At the level of the collar, the upper anchoring of the hanger is carried out by an articulated clevis, while at the lower level anchorage is on a tube supporting the deck. The installation of the suspension is the site's other special feature, as it took place in the final phase of execution. Prefabricated on the deck and supported by a temporary

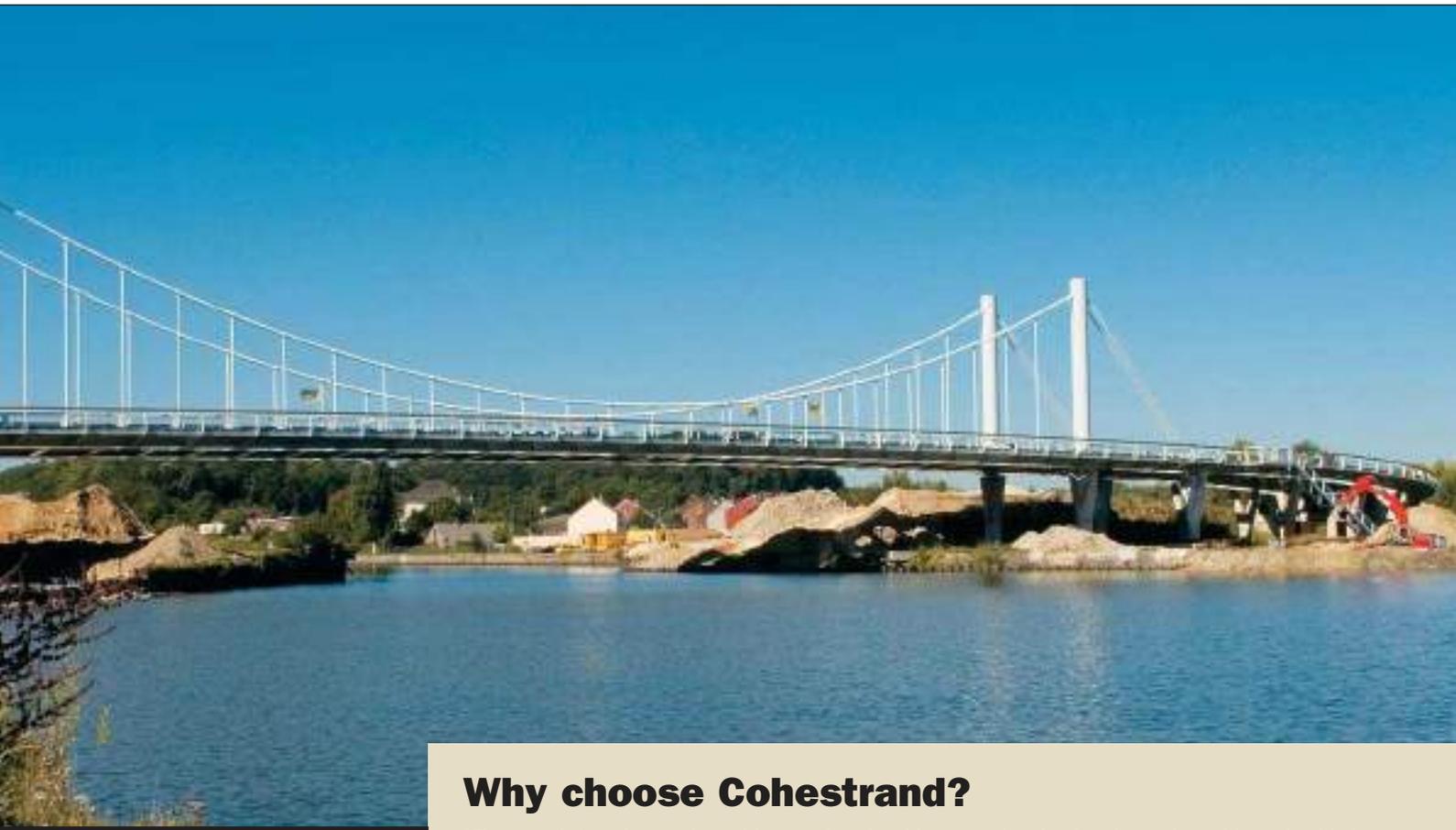
Composition of the Cohestrand strand

Main element in tension. 7-wire strand with a nominal diameter of 15.7 mm, a breaking strength of 1,860 MPa and a fatigue resistance of 300 MPa over 2 million cycles.

Protection against internal corrosion. Hot galvanization in accordance with standard NF A 35-035.

External corrosion protection: high density polyethylene (black HDPE, class PE 80 or PE 100) with a thickness of 1.5 mm, extruded on the strand and formulated to provide excellent aging resistance.

Binder: consists of a polybutadiene resin surrounding all the wires, including the central wire, and an element to guarantee adhesion to the polyethylene (this binding compound is a hydrophobic product, which is resistant to water vapour and oxygen and is capable of transferring the compression stress [flanging] and shear stress [tangential force of the hanger collar] from the polyethylene to the steel wires).



apparatus, the cables, fitted with their collars, were put into place on the pylons in two stages, using a crane for the first end, and by hoisting for the second. ■

Why choose Cohestrand?

“The need for the main cables to be durable naturally led to Cohestrand being chosen,” explains Benoît Lecinq, Freyssinet’s Technical Director, “as this cable was specifically developed by Freyssinet at the end of the 1990s to resist transverse flanging forces and longitudinal sliding forces and thus preserve the continuity of protection against corrosion at the level of the hanger collars on suspension bridges or deviation saddles on cable-stayed bridges.

Like the strands of a stay cable, with the petroleum wax replaced by a special resin in this case, the Cohestrand strands have a triple protection barrier

– galvanization, interwire voids and voids between wire and sheath filled with an adhesive polymer, and HDPE sheath extruded and adhered to the strand – the quality, homogeneity and reliability of which are the fruit of industrial methods. And, like parallel strand stay cables, the Cohestrand strands have a potential service life of 100 years by design. A full scale test was also carried out on a section of the main cable to test the sliding resistance of the collar. Conducted in August 2004 at the Freyssinet laboratory, it proved that the collar was capable of resisting a longitudinal force in excess of 1,200 kN before any sliding occurred.”

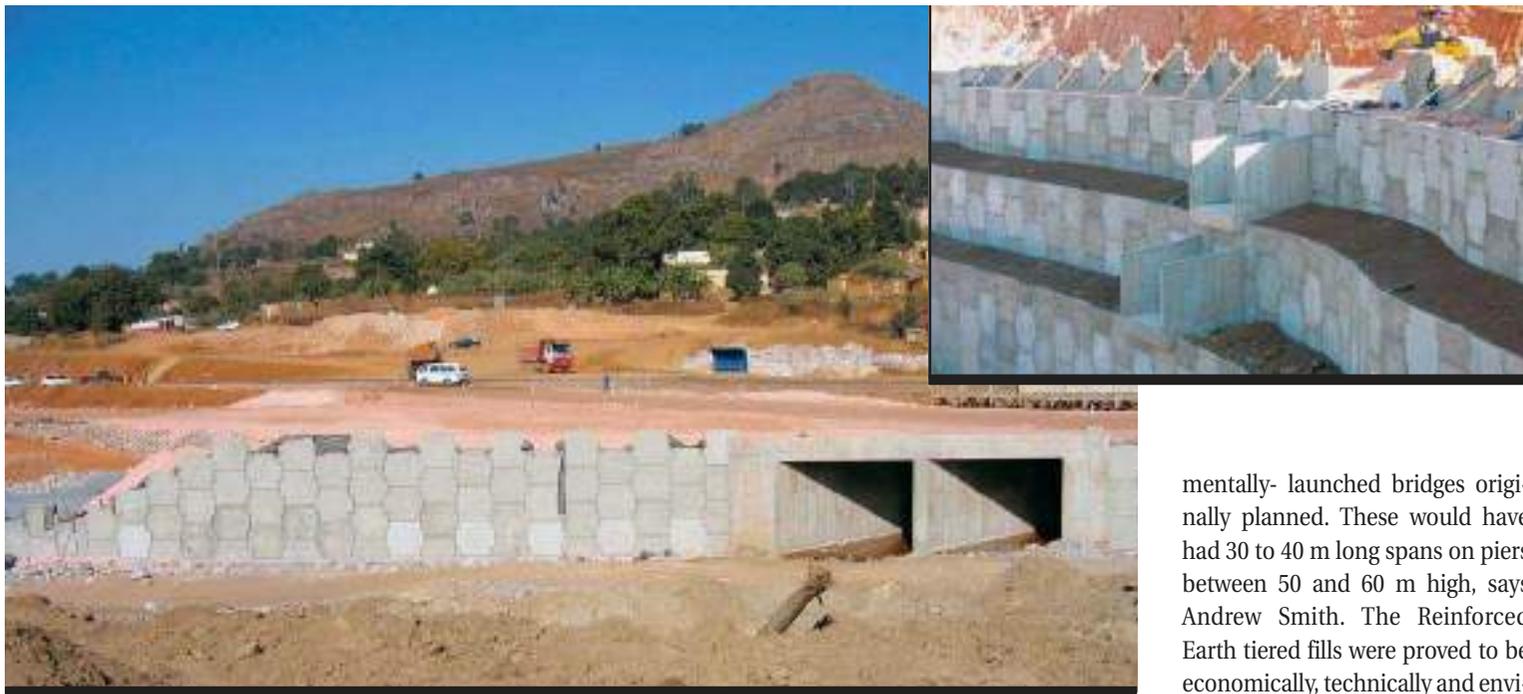
PARTICIPANTS

- ▶ **Owner:** Ministerie van de Vlaamse Gemeenschap Departement Leefmilieu en Infrastructuur Afdeling Maas en Albertkanaal.
- ▶ **General Contractor:** THV Herbosch Kiere Antwerpse Bouwwerken - Louis Duchêne.
- ▶ **Design Firm:** IV-INFRA.
- ▶ **Technical Inspection Service:** Seco.
- ▶ **Metal Construction:** Victor Buyck Steel Construction.
- ▶ **Specialist Contractor:** Freyssinet Belgium and Freyssinet.

VINCI Innovation Awards 2005: Grand Prize for Freyssinet



On 5 December 2005, Antoine Zacharias, Chairman and CEO of VINCI, presented the grand prize in the VINCI Innovation Awards 2005 to Benoît Lecinq (technical director of Freyssinet), Sébastien Petit (engineer within the "Cabled structures" division) and Ivica Zivanovic (product development manager) for the "Cohestrand suspension bridge cable system" used on the Kanne bridge. In addition to technical innovation, the panel highlighted "the level of technological excellence achieved by the Freyssinet teams with this product."



SOILS/MBABANE BY-PASS

A Record Contract for 36,000 m² of Reinforced Earth



In Swaziland, a relatively small Southern African country, Reinforced Earth has designed and is supplying materials for several massive tiered fills, numerous bridge abutments and retaining walls for the capital's by-pass link road.

MBABANE, THE CAPITAL OF SWAZILAND, a kingdom landlocked between South Africa to the west and Mozambique to the east and barely 17,300 km² in area, is currently served by two motorways, one from Manzini in the the south east, and the other, from the border town of Ngwenya in the north west. Whilst the first of these goes all the way to the city limit, the second currently ends about ten kilometres short of Mbabane, where it joins an

old motorway (called the MR3 Corridor), which is 5 km long and was planned to be modernized. In order to create a link between these two axes without splitting the city into two, the country's authorities have opted for a by-pass solution, for which construction work began in 2004. "We got involved with the Mbabane by-pass and MR3 road modernization projects very early on, in September 2002," says Andrew Smith, Director of the

Southern African Reinforced Earth subsidiary. The company's technical responses appear to have been persuasive and convincing. Two years later, Reinforced Earth signed one of its biggest contracts for designing and supplying 36,000 m² of Reinforced Earth structures with WBHO, the general contractor responsible for the construction.

789 km of reinforcing strips

The Reinforced Earth structures on the Mbabane Bypass comprise 14 retaining walls (totalling 5,500 m²) 12 true abutments and 4 mixed abutments for eight bridges (5,000 m²) and 4 tiered structures – Mangwaneni (9,500 m²), Qabalembadada (8,500 m²), Esitebeni (4,500 m²) as well as a wall used as an access slip road at Mangwaneni (3,000 m²) – all to be constructed by 2007. "The tiered walls supporting the line of the motorway were an alternative solution to the incre-

mentally- launched bridges originally planned. These would have had 30 to 40 m long spans on piers between 50 and 60 m high, says Andrew Smith. The Reinforced Earth tiered fills were proved to be economically, technically and environmentally acceptable solutions for containing the 35-metre high embankments. A 3m high 2m wide tier pattern was adopted for the tiers except for the Esitebeni structure which had to accommodate a service road and the Qabalembadada structure where the geometry dictated much higher tier walls. The constituent materials for the Reinforced Earth comprise weathered granite backfill TerraClass cruciform panels and HAR reinforcing strips (Reinforced Earth high adherence steel strips) 45 mm wide, 5 mm thick, with lengths varying from 4 to 22 m. "All the materials – a total of 1,735 t of steel, the equivalent of 789 km of reinforcing strip – are planned to be delivered before the end of 2005," concludes Andrew Smith. ■

PARTICIPANTS

- ▶ **Owner:** Swaziland Ministry of Public Works and Transport.
- ▶ **Consulting Engineers:** BCEOM/Otieno Odongo & Partners JV.
- ▶ **General Contractor:** WBHO South Africa.
- ▶ **Specialist Sub-Contractor:** Reinforced Earth (Pty) Ltd.

SOILS/MONDRAGON PLATFORM

New Generation Ballasted Columns

The new high-performance Ménard Soltraitemement crane makes it possible to increase the size of ballasted columns. Demonstration at Mondragon.

MORE POWERFUL, FASTER, MORE EFFICIENT... the new ballasted column machine jointly developed by Ménard Soltraite-

ment and Enteco under the code name E600 has many advantages. It has just been used for the second time in the field to consolidate

a 5,700 m² area of land at Mondragon (Vaucluse, France), where a plant specializing in the transformation of livestock slurry into compost is due to be built. "It is a complex process system that required complete control of absolute and differential settlements, particularly in the 2,500 m² area where a raft that will have to bear loads of 6 t/m² is going to be built," says Ménard Soltraitemement engineer Rémi Chatte. To treat the soil, which is made up of silt and clay to a depth of 6 m, 980 ballasted columns (5,500 m) were put in place according to a square mesh with side varying from 2 to 2.50 m. With a record production rate of 500 m per day (compared with 250 m with a conventional

machine), the work, carried out by a single shift of four people, lasted only four weeks. The advantages of this new machine do not stop there as they make it possible to establish the ballasted columns at a depth of up to 16 m. It can also deliver a pressure of up to 35 t when resting on its rear legs (25 t for conventional models), thus improving the quality of the ballasted columns (their peak resistance, tested using a static penetrometer, varies between 20 and 30 MPa). "We even set a record validated by a bailiff at the previous test site, recording a pressure of 38 t", adds Rémi Chatte. ■



PARTICIPANTS

- ▶ **Owner:** Société de distribution d'eau intercommunale.
- ▶ **Project Manager:** Safège environnement.
- ▶ **General Contractor:** groupement Spie-Batignolles Sud-Est - Mathis -Screg Sud-Est.
- ▶ **Specialist Contractor:** Ménard Soltraitemement.

STRUCTURES/MIRAGE TOWERS

57,300 m² of prestressed floors in Mexico

IN THE HEART OF LA LOMA, a residential district of the Santa Fe quarter in Mexico City, a complex with a total of 235 apartments has recently been built over an area of 15,000 m². In order to optimize the habitable area and lighten the structure of the Mirage Towers, three 17-storey buildings constructed above three underground car park levels, architect José Luis Camba Castañeda opted for the prestressed concrete slab solution. A total of 57,300 m² of prestressed floor surface was produced, using 160 t of extruded monostrands supplied and installed by Freyssinet de Mexico. ■

PARTICIPANTS

- ▶ **Owner:** Celta Bienes Raices, SA de CV.
- ▶ **Project Manager:** José Luis Camba Castañeda.
- ▶ **Specialist Contractor:** Freyssinet de Mexico.

STRUCTURES/NUCLEAR CONTAINMENT VAULTS

World-renowned expertise

As a prestressing specialist for nuclear power station containment vaults, Freyssinet has handled the installation of over one hundred projects in 13 countries over more than 30 years.



1. Construction of the foundations of the containment vault for the new EPR European reactor in Olkiluoto. **2.** Anchor point for the vertical prestressing for a containment vault in China.

IN THE STATE OF TAMIL NADU, in southern India, two VVER 1000 type reactors of Russian design are currently being installed near the town of Trivandrum on the Kudankulam site. For each of the two containment vaults, comprising a prestressed concrete shell 1,200 mm thick reinforced with a 6 mm metal interior impermeability liner, Freyssinet has installed 60 vertical inverted U-shaped prestressing cables, 53 horizontal cables looped on two ribs and 15 horizontal cables looped on the dome, all made up of 55-strand sheathed and greased bundles injected with cement grout before tensioning. “2,713 t of steel and

514 type 55 C 15 anchors have been installed,” says Jean-Lucien Mongauze, Business Engineer at Freyssinet. The strands are threaded one at a time into a flexible sheath in the case of horizontal cables, and into rigid tubes for vertical prestressing. As un-bonded prestressing is used, load-check, re-tensioning or replacement operations can be carried out later if necessary. In China, Freyssinet has just finished installing the prestressing for two containment vaults at the Tian-wan power station near the city of Lianyungang in Jiangsu province. Freyssinet is also providing assistance for the construction

of two nuclear power stations named Ling-Ao phase II and Qinshan Extension phase II by supplying and installing the prestressing for the containment vaults (37 m in diameter and 56.70 m high). The first is an extension of the Ling-Ao phase I power station (itself an extension of the Daya Bay power station), constructed in the province of Guangdong south of Shenzhen between 1997 and 2002 and equipped with two 900 MW PWR reactors. The prestressing system used is made up of 176 19 T 16 dome cables, 224 horizontal cables of the same type and 145 37 T 16 vertical cables. This amounts to 2,506 t of strands, 1,600 19 K 16

anchors and 580 37 K 16 anchorages. The second project, Qinshan phase II, relates to the enlargement of the Qinshan II power station, which was built between 1996 and 2002. Less powerful than Ling-Ao with a power production capacity of 600 MW, this power station was largely designed by Chinese engineers. For the containment vaults, 174 19 T 6 dome cables, 199 19 T 16 horizontal cables and 144 37 T 16 vertical cables were put in place by the general contractor with the technical assistance of Freyssinet. In Europe, Freyssinet is working in Finland on the new EPR (European Pressure Reactor) construction project on the Olkiluoto site. This is

an exceptional programme which, for the protection of the reactor, requires a non-standard double shell comprising a 1,800 mm thick shell to protect against plane crashes covering the entire nuclear island and an internal vault 1,300 mm thick, with a 6 mm-thick metal liner on the inside to guarantee impermeability. Acting on behalf of Framatome, Freyssinet is supplying a turnkey service for the provision and the installation of prestressing for the internal containment vault. Thus 104 54 T 16 gamma cables, 119 54 T 16 horizontal cables and 47 54 T 16 vertical cables have been installed, with a total of 2,050 t of strands and 540 55 C 15 anchors.

Installation and inspection

“The containment vault is the ultimate barrier in the event of an accident,” points out Jean-Lucien Mongauze. This means that its construction and the installation of prestressing are matters for specialists that must comply with stringent quality requirements and that require very strong cables. Since its first involvement in the French nuclear programme with EDF during the 1970s, Freyssinet has continued to improve its prestressing system. In particular it has developed new injected grouts and improved the impermeability

and rigidity of ducts by using rigid tubes for the vertical parts or parts with large curves, as well as thermoshrinkable sleeves and injection connections.

Freyssinet’s current offering comprises several types of prestressing chosen to take account of the technical specifications, the maintenance, the replacement and the life time of nuclear plants.

In addition to these installation services, Freyssinet offers its customers inspection and monitoring of the prestressing during and after the works. “We have various measurement systems available to us,” says Jean-Lucien Mongauze. In some cases, as well as extensometers with vibrating cords that give information regarding the status of the stresses within the concrete, we also equip a few cables of each type with dynamometers. In the other cases, we also have the possibility of load-checking all the cables using the lift-off method and checking for the presence of any corrosion by detensioning and examining some of the strands during power station maintenance shutdowns. Freyssinet will also design and supply gondolas and service towers to provide access to the cables and to install and inspect them during the lifetime of the power station. ■

SOILS/CALARASI PLATFORM
Record Output



DURING THE SUMMER, Ménard Soltraitement put a great deal of effort into successfully completing the improvement of a 21,500 m² platform in Romania. For the construction of its new flat glass manufacturing plant, a project involving in particular a 21,500m² storage warehouse that will have to bear a live load due to use and occupancy of 8 t/m², Saint-Gobain chose the town of Calarasi, approximately 100 kilometres east of Bucharest, a site where the soil conditions (compressible collapsible loess and soft clay) and the seismic risk made strengthening necessary. The Ménard Soltraitement solution was finally chosen in preference to the initial plan for a floor supported on piles. It consisted in installing conventional paving with a thickness of 25 cm resting on soil strengthened by a network of CMCs (controlled modulus columns) via a sand-gravel mixture distribution cushion with a thickness of 60 cm. “With this solution we were able to guarantee absolute settlement of around 3 cm and differential settlement of less than 1/500°,” says Philippe Liausu, Managing Director of Ménard Soltraitement. In order to carry out the work within the very

In July and August, the two CMC rigs enlisted consolidated the platform that will hold the new Saint-Gobain plant in Romania.

tight deadlines without risking prohibitive penalties for delay, in July and August last, the company enlisted two CMC rigs and installed 3,900 CMCs with a 360 mm diameter (equivalent to 65,000 linear metres) according to a 2.25 m square mesh at a mean depth of 17 m. The sustained rate allowed us to achieve a production record of 1,740 linear metres of columns for a one workshop working one 12-hour shift, equivalent to approximately 200 m³ of mortar. “We also had to use three concreting plants so that we could produce the 8,000 m³ of mortar we needed,” adds Philippe Liausu. The mobilization paid off: the company delivered the work three days ahead of schedule. ■

PARTICIPANTS

- ▶ **Owner:** Saint-Gobain.
- ▶ **General Contractor:** Hervé.
- ▶ **Technical Inspection Service:** Socotec.
- ▶ **Specialist Contractor:** Ménard Soltraitement.



256 prestressing cables were installed in the two containment vaults in Kudankulam (India).



SOILS/KWANG YANG PLATFORM

Atmospheric Consolidation over 350,000 m²



At Kwang Yang (South Korea), the Menard Vacuum process makes possible to consolidate land claimed from the sea.

SOUTH KOREAN AUTHORITIES have decided to make the port of Kwang Yang, located in the south of the country near Yosu, one of the most dynamic port areas in Asia. This implies an increase in container storage capacity and the number of unloading docks at the site. Titanic sea filling works have therefore been underway at the port for several years. The operation consists of filling immense racks formed by dykes of rocky ballast with dredged clay on the soft marine clay sea bed; the quay edge is made up of concrete caissons submerged in the sea. As the resist-

ance of land obtained in this way is very poor, consolidation was necessary. "The treatment by atmospheric consolidation (Menard Vacuum process) we suggested was chosen in 2003 for treating an initial platform of 295,000 m² (lot 3-1) which has just been delivered," says Daniel Berthier, vice chairman of Sangjee Menard. "The company has just begun work on a second area of 55,000 m² (lot 3-2)." The implementation of the process involves several stages. In the case of lot 3-2, the clayey submarine deposits are approximately 15 m thick and are topped by the hydraulic dredging backfill to

+ 8.50. There is therefore a total of 25 m of very soft, waterlogged clay, onto which a geotextile is unrolled. This is then covered with a sandy draining cushion and a layer of ungraded aggregate.

A Network of Drains

"This is the point where Sangjee Menard comes into action to install cylindrical vertical drains in the soil in a 1-metre square mesh," explains Daniel Berthier. From June 2005, 55,000 drains (1,300,000 lm) sunk to a depth of 26 m underground were installed in just under one and a half months with the mobilization of two installation teams turning out 12,000 m per machine per day. Subjected to the pressure of the backfill

(and, later, to the pressure drop created by pumping), the water trapped in the clay flows up toward the upper layer of sand where it is collected by a system of horizontal drains, which are connected to pumps. In order to increase the imperviousness of the system and in particular to counteract the harmful effect of sand lenses in the dredged clay, a slurry wall made of secant piles was constructed on the entire circumference by mixing the in situ soil with a bentonite/cement grout. In addition, interconnected steel sheets were put onto the upper part of the slurry wall in order to improve its effectiveness. An HDPE membrane with a thickness of 1.50 mm, sealed into the clay in the trenches dug out above the slurry wall and covering all of the backfill, completes the installation. Then, after meticulous checking of the system for leaks, pumping was activated. As the pumps create a vacuum under the membrane and remove the water from the soil, the ground is restructured by settlement. This underground work is supplemented at the surface by the excess load effect of backfill placed above the membrane. On the lot on which work has just started, a global settlement of 7 m is expected in a 12 months period, with residual settlement guaranteed for 10 years, of 10 cm in primary consolidation under an operating load of 5 t/m². ■



The underground network of 1,300 km of drains connected to pumps will allow for the soil to be restructured within 12 months.

STRUCTURES/THE LA SIOULE VIADUCT

1,200 t of Multiple Prestressing Strands



In the Puy-de-Dôme, work has just been completed on the largest concrete viaduct in France, a structure in which prestressing is present throughout.

IN THE AUVERGNE VOLCANOES NATIONAL PARK, between the villages of Bromont-Lamothe and Saint-Ours-les-Roches, construction of the la Sioule viaduct on the A89 (Clermont-Ferrand – Bordeaux) was completed last September. Designed by the Société d'études et de calculs en ouvrages d'art (Secoa) and architect Berdj Mikaelian, the structure comprises a single concrete box-girder, the height of which varies from 5.50 m at the midspan stitch to 10 m at the piers. Its eight spans, the two central ones stretching 192 m each, rest on hollow reinforced concrete piers, the highest of which rises to 135 m.

1,200 Tonnes of Steel

For the deck, the Campenon Bernard-Dodin group of companies (VINCI Construction) chose the balanced cantilever construction method with segments cast in situ and entrusted the prestressing to Freyssinet. "It would be more accurate to say the "prestressings," says Alain Ghenassia, Freyssinet's Rhône-Alpes regional director. "They all use our C system and represent a total of 1,200 t of steel." Chronologically, a transversal prestressing injected with cement grout was first applied to the lower hollow block of the segments on piers (themselves "tacked" to the pier heads using two or four 19T15

cables according to the piers). On the upper part of the segments, in the upper block, monostrands were then installed transversally every 250 mm. "We suggested using sheathed and greased strands as an alternative to a solution that would have required larger units and would therefore have been more difficult to install," explains Alain Ghenassia. During the construction of the spans, initial interior prestressing was installed to tie the segments together and take the inherent weight of the structure. Anchored per pair of segments on either side of the piers, these cables are formed of bundles of 19 bare 15.70 mm strands inserted into a metal sheath injected with cement grout, the longest of which is 200 m in length.

Finally, external continuity prestressing by cables (31C15) measuring up to 250 m was installed in the caisson between December 2004 and July 2005 to carry the structure's operational loads. Inserted into a

The deck houses two sets of prestressing: one tying the segments together on either side of the piers, the other bearing the structure's operational loads.

black HDPE sheath injected with petroleum wax in accordance with CIP (Commission inter-ministérielle de la précontrainte/interministerial prestressing commission) recommendations, these can be re-tensioned or even individually replaced if necessary.

After 36 months of civil engineering works, the viaduct will open to traffic at the beginning of 2006. ■

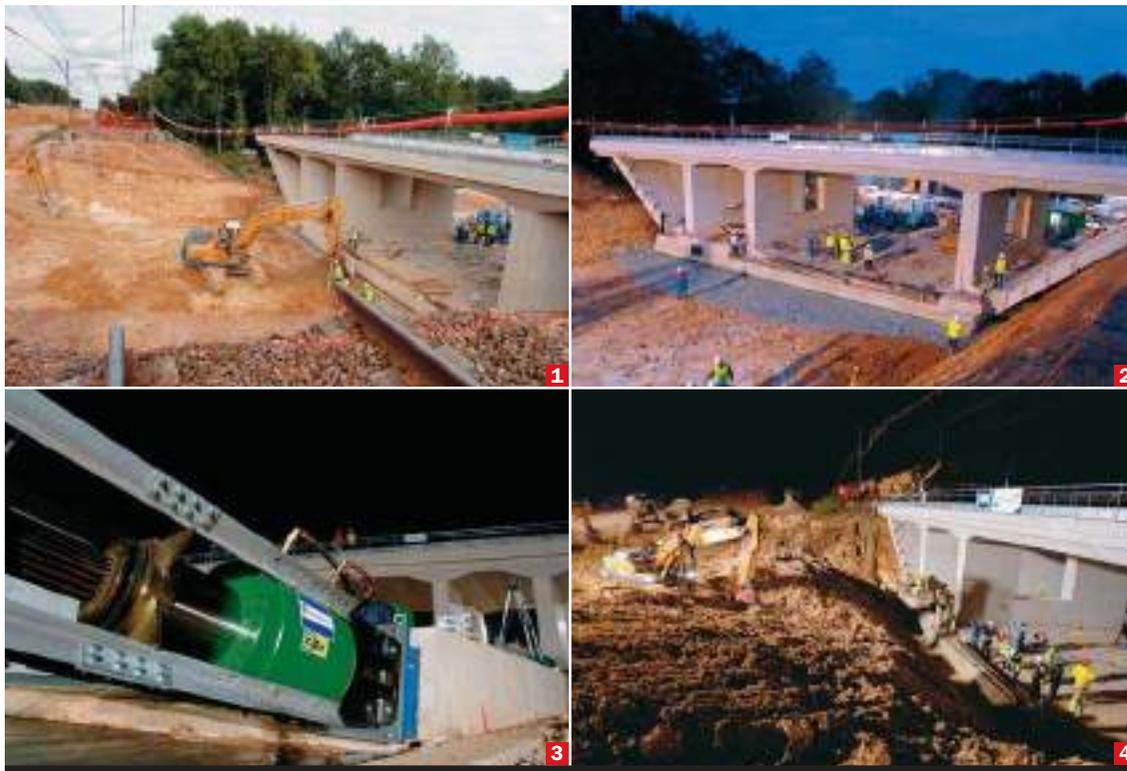
PARTICIPANTS

- ▶ **Owner:** Autoroutes du Sud de la France.
- ▶ **Project Manager:** Setec TPI.
- ▶ **Designer:** Secoa.
- ▶ **Architect:** Berdj Mikaelian.
- ▶ **General Contractor:** Campenon Bernard TP-Dodin JV.
- ▶ **Specialist Contractor:** Freyssinet.



STRUCTURES/SAINT-CHÉRON RAIL BRIDGE

Express Method for a Railway Bridge



Acquired by Freyssinet at the beginning of the year, the Autoripage® technique makes it possible to put a structure in place on a railway line with rail traffic interrupted for only a few hours. Illustration in Saint-Chéron (France).

IN THE TOWN OF SAINT-CHÉRON (ESSONNE), the level crossing on the Brétigny-Tours line is now just a memory for motorists. They can now cross the railway line with the greatest of ease thanks to the restructuring of the RD 116 road and the construction of a rail bridge, which was installed within a few hours thanks to Autoripage®, a technique that was added to the Freyssinet construction offering with the acquisition of the company JMB Méthodes last January.

50 metres in 5 hours

“We allowed a window of 12 hours for safety, but in the end we only needed 5 hours to carry out the manoeuvre and slide the structure from its prefabrication area to its final location,” says Jean-Luc

As it only requires small teams to work on the lower part of the structure, the technique is also beneficial in terms of risk prevention.

Bringer, Director of the SCCM (Service centralisé câbles et manutention/Centralized Cables and Handling Service) unit at Freyssinet. This time saving of several hours was in fact part of a much greater time saving if you consider the project as a whole. “The conventional solution would have been to build a bridge directly on the route and move rail traffic onto a temporary structure, which would have led to a significant reduction in average train speed, or sometimes trains even having to be stopped,” explains Jean-Marie Beauthier, inventor of

the process. With Autoripage®, the bridge is entirely prefabricated in an area adjacent to the railway embankment before being put in place. Apart from for the very limited time needed for this operation, which means stopping traffic for between 10 and 48 hours, train traffic is not disrupted at all while the structure is being built.

Placed on its raft 50 m away from its final location, the Saint-Chéron rail bridge was a 2,400 t structure with a length of 35 m and a skew of 74 degrees with two central spans, one for road traffic (12 metres wide), the other for cyclists (4m wide), flanked by two approach spans. The bridge was put in place by sliding using a system of cables and three jacks used as linear winches with a unit capacity of 1,000 t and a stroke of 350 mm, specially designed for this type of activity by Hebetec, the Freyssinet subsidiary specializing in heavy load handling. “Using this system we can reach a maximum pushing speed of 12 to 13 metres per hour,” says Martin Duroyon, Section Engineer at Freyssinet. At Saint-Chéron, this pace was reduced by half to allow the excavators to clear the embankment ahead. This team operation also received a contribution from Advitam, a company associated with the VINCI Group, which developed a monitoring system to ensure centralized control of the jacks and monitoring of the structure’s movement (measurement of displacements and loads, altimetric and lateral movements).

Autoripage®: the principle

Invented by Jean-Marie Beauthier in 1992, the Autoripage® technique

STRUCTURES/KONIN BRIDGE

Incremental launching on the River Warta

consists of moving an entire structure such as a rail bridge from its prefabrication area to its final location within a very short time, thus limiting interruptions to rail traffic to between 10 and 48 hours. The structures to which it is applied are assembled on a raft and comprise two approach spans supported by struts inclined at 45°, which replace the traditional ripraps (this configuration makes it possible to avoid filling operations around the structure at a later stage and the construction of a transition slab or wing walls). The actual Autoripage® operation involves sliding the structure to its final location on the soil on a bed of lubricating bentonite-based grout using a system of cables and hydraulic jacks. As the structure only exerts very low pressure on the soil (0.3 to 0.7 bar), Autoripage® can be used on any type of ground. Since the takeover of JMB Méthodes by Freyssinet, several structures have been constructed using this technique in Thonon-les-Bains, Thaon-les-Vosges, Saint-Rémy-lès-Chevreuse, Chalon-sur-Saône, in Luxembourg, etc. ■

IN KONIN (POLAND), on the Warsaw to Poznan motorway, Freyssinet Polska, the Group's Polish subsidiary, has assisted with the construction of a new steel bridge by handling the incremental launching operations above the River Warta. Generally curved in shape, the structure measures 440 m and comprises five rectilinear spans. The deck was put in place in 220 m (780 t) sections in two phases, in July and August, in only five days. "The main difficulty we encountered," explains Anna Oldziejewska, Marketing Manager at Freyssinet Polska, "was in the arc-shaped geometry of the structure, and its lower wings, neither the width nor the height of which were constant." To compensate for



these differences and to allow the structure to rest axially on the supports, mobile 'auto-centred' devices (specially designed by Freyssinet for this structure) combined with five jacks with a unit capacity of 30 t were used.

The actual incremental launching required the use of four jacks with a stroke of 60 mm using a force of 892 kN. Once the incremental launching operations were finished, Freyssinet Polska installed 60 pot bearings. ■



STRUCTURES/GAEGOK BRIDGE

A 100% Freyssinet Project



In South Korea a new motorway section passes through a particularly hilly area close to Gaegok and crosses a structure that is 280 m long (and 20 m wide), which Freyssinet Korea will be building in

its entirety, including the civil engineering. Resting on piers of up to 50 m in height, the deck comprises five cantilevered spans (70, 50, 55, 35 and 70 m) and has interior pre-

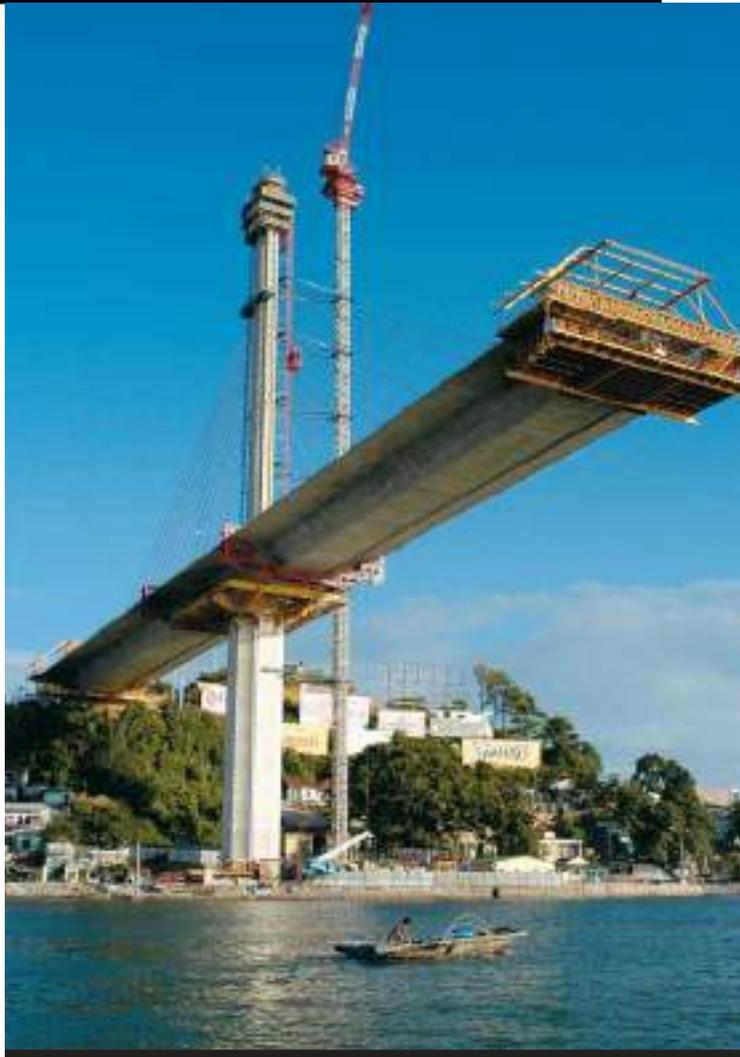
stressing made up of un-bonded 19C13 cables (220 t). "Our team on site, made up of 35 people, build one segment on each side of the piers every 18 days," says Jong Tae Han, Works Director at Freyssinet Korea. The abutments are built on scaffolding. When the structure is completed in June 2006, the Freyssinet Korea teams will remain in the region and will begin work on another structure on the same route, the Beobgy I Bridge, with a 20 m wide, 180 m long deck. ■

PARTICIPANTS

- ▶ **Railway Works Owner:** RFF.
- ▶ **Road Works Owner:** Conseil Général de l'Essonne
- ▶ **Assistant Project Manager:** SNCF Rive Gauche
- ▶ **Project Manager:** SNCF-EVEN Val d'orge
- ▶ **General Contractor:** Guintoli
- ▶ **Autoripage:** Freyssinet France, Service centralisé câbles et manutention (SCCM)
- ▶ **Design and Methods:** JMB Méthodes

PARTICIPANTS

- ▶ **Owner:** Gyeongsangnam-do.
- ▶ **General Contractor:** Daewoo E&C Corporation.
- ▶ **Specialist Contractor:** Freyssinet Korea.



A central layer of stay cables, narrower protective pipes in special colours: three solutions to help the structure blend into the panorama.

STRUCTURES/BAI CHAY BRIDGE

Landscaped Stay Cables on Halong Bay



In the Gulf of Tonkin (Vietnam) on the edge of Halong Bay, construction of the Bai Chay Bridge is in progress. The structure is fitted with the latest generation of Freyssinet stay cables and pipes.

LOCATED ON THE ROUTE OF THE FUTURE MOTORWAY No. 18, which will connect Noi Bai International Airport to the north

of Hanoi to Bac Luan on the Chinese border, in 2006 the Bai Chay Bridge will cross a sea inlet overlooking Halong Bay and will be the

key to the economic development of a high-potential region, which is stimulated by both the location of the industrial city of Haiphong alongside the motorway and the Bay's significant tourist and port activity.

With a central span of 435 m and a total length of 903 m, the Bai Chay bridge is larger than the Elorn (France), Sunshine Skyway (United States) or Coatzacoalcos (Mexico) bridges and breaks the length record for prestressed concrete bridges supported by a central layer of stay cables. "The arrangement of the stay cables does not reflect a desire to break a record," explains Roger Raymond, Freyssinet Area Manager, "but rather an effort to enhance a UNESCO world heritage site." With two lanes of traffic in each direction as well as two footpaths, the deck, comprising segments cast in situ, is 25.30 m wide. The cantilevered structure will be supported by 112 stay cables anchored into two pylons reaching a height of more than 137 m.

A Special Pipe

Depending on their location, the bundles of cables are made up of 37 to 75 strands and their length varies from 50 to 230 m. All of them are fed into a 'low drag stay pipe', which is fitted with a specific device to prevent vibrations linked to the combined action of the wind and rain. The originality of the Bai Chay pipes goes further, as the owner wanted to use three shades of yellow on them to create shaded tones in trompe l'oeil reminiscent of a sunset from the centre of the pylons outwards. "Thanks to its mastery of stay cable technology, Freyssinet was able to respond favourably to this request," says Benoît Lecinq, Freyssinet's Technical Director. "Our R&D work has enabled us to find formulations for the sheaths to allow the designers to give their architectural expression free rein. Freyssinet offers its customers pipes in various colours that preserve their mechanical properties and their resistance to ultraviolet rays." To absorb vibrations, the bridge will also be equipped with three types of internal damper depending on the length of the stay cables. 20 internal radial dampers (IRD) per pylon will be installed on the longest cables, 20 internal hydraulic dampers (IHD) for intermediate lengths and 16 internal elastomeric dampers (HDR) for the shortest ones.

PARTICIPANTS

- ▶ **Owner:** Socialist Republic of Vietnam – Transport Ministry – Project no. 18.
- ▶ **Finance:** Japan Bank for International Cooperation.
- ▶ **Project Manager:** Japan Bridge & Structure Institute Inc. ; Pacific Consultants International; Transport Engineering Design Incorporation; Hyder Consulting-CDC Ltd.
- ▶ **Specialist Contractor:** Freyssinet.

CMC OPERATOR: CONSTANT VIGILANCE

«When we arrive at a site,” explains Mathieu Prot, a Controlled Modulus Column Operator (see below) for Ménard Soltraitement, “the first thing we do is check the equipment in its entirety – that is, the crane, its mast and the concrete pump supplying it – and make sure everything is working properly. Installing CMCs leaves no room for improvisation and the type of concrete we use means we have to work non-stop.” As soon as he has finished his check-up, the operator goes to his workstation, a cabin with control levers arranged next to a computer screen. He will only come out again once the concrete supply to the pump has been used up (45 or 90 m³ depending on the model).

On the ground, marking set out by the Ménard Soltraitement engineers shows him the exact position of the CMCs to be installed. Guided by a manoeuvre that controls the movement of both the pump and a tracked remote-controlled device, the operator places the auger accurately on the marks, ensuring that the mast is vertical and if necessary adjusting it using an inclinometer. As soon the auger starts to penetrate the soil, all the drilling param-

eters are recorded by the computer in real time. The operator then has to carry out a variety of tasks simultaneously – careful monitoring of the verticality of the mast and the work of the auger, its turning torque and the depth it reaches. All



this data is conveyed to the operator as well as to the onboard computer by the rotation table fixed to the mast, “a real concentration of high technology,” covered with sensors.

As well as being used for monitoring the operation and calling for immediate corrective decisions or actions, the data collected also pro-



For the operator, nothing is left to chance: the positions of the CMCs are rigorously marked out by the engineers and all the performance data is recorded by the onboard computer.

vides traceability of the work and is often passed on to the customer or design firm by Ménard Soltraitement. Once the required depth has been reached, the operator begins the second implementation phase, which requires just as much attention, as the mortar must now have been incorporated in the correct proportions and its pressure checked.

Linked to the nature of the soil, the number of CMCs completed daily varies, but is in fact measured in metres. On average, Mathieu Prot estimates that he does 500 to 600 m per day.

With machines that are performing better all the time – in particular guaranteeing the vertical adjustment of the automatic mast – the CMC operator's job is changing and is becoming more specialized and demanding, which also explains why mostly experienced operators are sent to the site under the supervision of a Section Engineer. ■

Semi-rigid cemented inclusions

A soil reinforcing process, controlled modulus columns (CMC) are semi-rigid cemented inclusions with distortion modules that are 5 to 30 times lower than those of concrete. In practice, CMCs are made using a special auger that pushes back the soil, and this technique, which does not require either vibration or driving, does not affect the environment. The tool is screwed into the soil to the required depth and then brought back up with no spoil. A fluid grout is then put into the soil by the core of the hollow auger (the special auger) to form a column of cemented material approximately 25 to 60 cm in diameter, which withstands stresses of 10 to 50 bar depending on the proportions of the mixture.

A COMPREHENSIVE OFFERING IN SOUTH KOREA

In just over 10 years, Freyssinet Korea and Sangjee Menard have successfully deployed all the know-how of the Group in Korea by signing a number of prestigious contracts

Freyssinet Korea

Although the presence of Freyssinet in South Korea goes back to September 1989, when the Group opened a representative office in Seoul, the company has only been formally registered under the name of Freyssinet Korea since 1993. Made up of five people, the company was then directed by WS Park and JY Kim, who has been Managing Director since 1999. Initially involved in prestressing works and structural equipment, Freyssinet Korea came to a significant turning point with the Seohae bridge site in 1995. "For that structure," said JY Kim, "we took care of the prefabrication of the segments for the 52 spans of the two decks, heavy lifting, segment laying, prestressing, carriageway joints and stay cables." This extensive service enabled the company to gain the status of a

VITAL STATISTICS

- ▶ **Employees:** 66 executives, technicians and administrators, 201 manual workers.
- ▶ **2004 Sales Figures:** 21,640 million won (18 million euro).
- ▶ **Managing Director:** JY Kim.

major public works player. Finding itself in a boom situation after this success, the company added repairs to its portfolio of services and in 1997 signed up for its first project, the strengthening of a cantilever bridge. The company then worked on five major projects over the next few years: the installation of the segments for a high speed rail bridge using the MSS (movable scaffolding system); the launching of the Jang-An Bridge and the installation of stay cables on the Samcheonpo, Yeong-Heung and Namdo bridges (bow-string).



1



2



PEOPLE AT FREYSSINET KOREA

Some of the Freyssinet Korea management team: Ji Yeong Kim (1), managing director; Byung Joo Huh (2), chief of the Reinforced Earth department; Ki Chul Won (3), marketing manager; Jong Tae Han (4), construction manager; Yoon Ik Cha (5), procurement and equipment manager; Sung Woo Kim (6), finance and administration manager; Hyun Kwon Hong (7), chief of the technical department; Sang Jin Park (8), geotechnical division manager; Seung Ik Kim (9), Structures division and technical manager.



1. Between 1998 and 2000, Freyssinet Korea assisted in the building of the Seohae bridge, a 7,310 m structure across the bay of Asan, by designing a self-launching truss for the construction of the spans and supplying and installing the prestressing for the pylons and stay cables.

3. Between 1999 and 2000, Freyssinet Korea carried out all of the superstructure construction, prestressing and launching work on the 525 m Jang-An bridge, 100 km south-west of Seoul.

2. In soils, Freyssinet Korea is to complete its first TechSpan arch project in 2006 on the Cheongwon-Sangju motorway. The structure will require the installation of 524 half-arches.

Support from Reinforced Earth

In the meantime, the company once again expanded its offering by adding Reinforced Earth and TechSpan prefabricated arches. As soon as they were recruited, the geotechnical engineers saw a string of Reinforced Earth projects, which led to Freyssinet Korea approaching Reinforced Earth, the Group's Australian subsidiary, in order to benefit from its expertise and support for staff training for the first designs. Australia also came to the aid of Korea when the first orders for TechSpan arches were taken in 2005 for the construction of two covered trenches on the Cheongwon-Sangju and Taebaek-Seohak

motorways. At the same time, the deployment of structural skills continued with the introduction of floor prestressing (Samsung Leeum Museum) in 2003, followed by the Cohstrand strand and deviation saddles, which will be implemented in 2006. ■

Sangjee Menard



In the Land of the Morning Calm, soil improvement works are handled by Sangjee Menard, an equal shareholding joint venture set up in 1992 between the Korean company Sangjee Co. Ltd and Ménard Soltraitement, which handled its first project at the Honam-Oil refinery in Yeosu in 1993 (70,000 m² of dynamic compaction and dynamic replacement). In 1995, the work for a second phase at Honam-Oil, similar to the previous phase, and the use of the Menard Vacuum process on the platform of the Kimhae water treatment plant (85,000 m²) confirmed the company's status as a soil treatment specialist. From 1997, the Jangyoo water treatment plant was handled by Menard Vacuum (70,000 m²).

After restructuring the capital of the joint venture, Ménard Soltraitement increased its shareholding to 80% in 2003. The group is currently managed by Ki Hyun Song, who is also the Chairman of Sangjee, and by Daniel Berthier, vice chairman and Ménard Soltraitement's representative in the country. In 2004 the company achieved sales of 7 M€; it has 11 employees working on site and eight people at the head office. It is currently handling its largest project yet at Kwang Yang in the south of the country (see page 22).



1

2

PEOPLE AT SANGJEE MENARD

Ki Hyun Song, chairman of Sangjee Menard; Daniel Berthier, vice chairman of Sangjee Menard and Ménard Soltraitement representative for South Korea.

FROM JACKS TO COMPUTER-

Freyssinet, a pioneer in the use of jacks for handling and lifting, has played an active role in the development of this technology. Coupled with an IT system, this technology now allows for manoeuvres to be carried out with micrometric precision.

1930/1940



In 1932, to strengthen the foundations of the marine terminal at Le Havre, which were subsiding by 1 to 2 cm per month, Eugène Freyssinet suggested the installation of new piles using piston-boring jacks. At that time, jacks were only used for organizing or reorganizing internal structural loads.

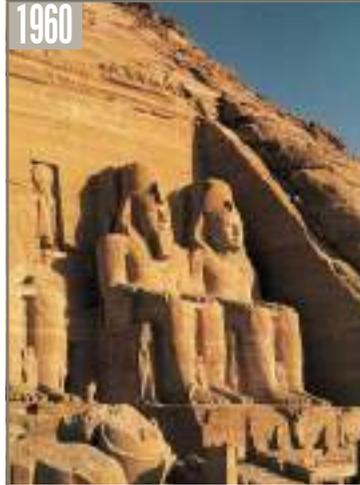
Eugène Freyssinet invented flat jacks in 1938. For the first time he used them on the **Beni-Bahdel dam** in Algeria, and then for the construction of the bridges over the Marne in 1946 to adjust the thrust of the depressed arches using both flat jacks and wedging.

1950

In 1956, the business, which was then called Stup (Société technique pour l'utilisation de la précontrainte - Technical company for the use of prestressing), specialized in the reorganization of stressing for structures and flat jacks to carry out low amplitude movements of those structures. This method strength-

ened the bells of the La Chaise-Dieu church in Haute-Loire, a monument dating back to the fourteenth century. During this period, the company played an active part in the development of handling and moving loads by studying the launching and shifting of straight beams for bridge construction.

1960



On the construction site of the storage ring for the Orsay linear accelerator, built during the 1960s, the company supplied flat jacks to level the structure. During con-

struction these structures were mastered with excellent accuracy. This usage opened a new approach to using jacks: in addition to controlling forces and strain, the Stup engineers turned their attention to the movement and displacement of horizontal and vertical loads. The company was involved in several projects of this type, in particular the displacement of the **Abu Simbel temples** in Egypt during the construction of the Aswan High Dam over the Nile in 1967, and then in admittedly less spectacular projects lifting numerous road bridge structures for the bearings to be changed.

1970



Keeping bridge clearances in motorways after reballasting impose sometimes to raise the structures, therefore exceeding the stroke of flat jacks and thus requiring the use of mechanical jacks.

The change in bridge clearances due to motorway construction saw the introduction of mechanical jacks, which had greater stroke than flat jacks. This was also when Freyssinet carried out the first 'step by step' lifting during the construction of the **Libourne water tower**. The 1.000 m³ vessel was constructed and cast on the ground, then lifted as the tower was built using 24 75 t jacks with a stroke of 20 cm placed on pillars composed of match-cast joints elements. Other structures of this type were built in the same manner such as in Saint-Lô (Manche) and in the Middle East. The technique remained rather rudimentary: an equal volume of oil was injected into each jack. Manual adjustments were required to correct any discrepancies.



AIDED LIFTING: THE RISE OF LIFTING

1980



show displacement readings, making it possible to act on each channel to make corrections. The Cipec subsidiary developed its own system. In 1989, Freyssinet was called in to level eight hammerhead piers on the site of the Barrières du Havre viaduct, using 12 simultaneous lifting channels. The first computer-aided lifting machine was used to carry out this delicate operation. A computer automatically halts the process in the event that the tolerance is exceeded and adjusts the level position. Using this revolutionary approach, the system relies on the processor's low resolution speed, which controls the accuracy within a millimetre. The system quickly established itself, paving the way for the development of cable and jack lifting, which is more effective and popular with construction companies. In 1983, the lifting of the **Saint-Quentin-en-Yvelines water tower vessel** was the first in a long series.

The growing interest in construction on the ground and putting the structure in place at a height gave respectability to jack lifting, which became a recognized construction method used by professionals. In 1982, Freyssinet pioneered the **synchronized plant technique**, which was perfected by Pierre Guinard. An equal volume of oil is injected into eight jacks simultaneously; electronic displays assembled on the equipment

1990



In 1992, Freyssinet's engineers worked on the development of a lifting machine controlled by a programmable logic controller (PLC). Since then, tasks have been distributed as follows: a processor carries out the calculations while a PLC controls the functions. Errors due to the opening and closing time of the solenoid valves have been reduced. Speed has increased considerably and accuracy is now within a tenth of a millimetre for both lifting and lowering. Each machine comprises several lifting

channels and can be connected to other machines that it monitors, allowing for infinite combinations. The use of sensors further improves the system's performance, which no longer requires a fixed point of reference on the ground to locate positions in space. In 1996, 240 jacks synchronized using this system were used to decentre the reinforced concrete cover slabs on **building F at Paris Charles de Gaulle (Roissy) Airport** to deform the steel hanger structure without buckling the cover slabs.



2000



Developing the heavy lifting activity (such as the lifting of the roof of the Cam-pione Casino in Switzerland – Photograph above) Freyssinet strengthened its offer with the acquisition in 2004 of the Swiss company Hebetec, a specialist in lifting, lowering and moving heavy loads, to expand its range of services.

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