Soils&Structures

THE FREYSSINET GROUP MAGAZINE

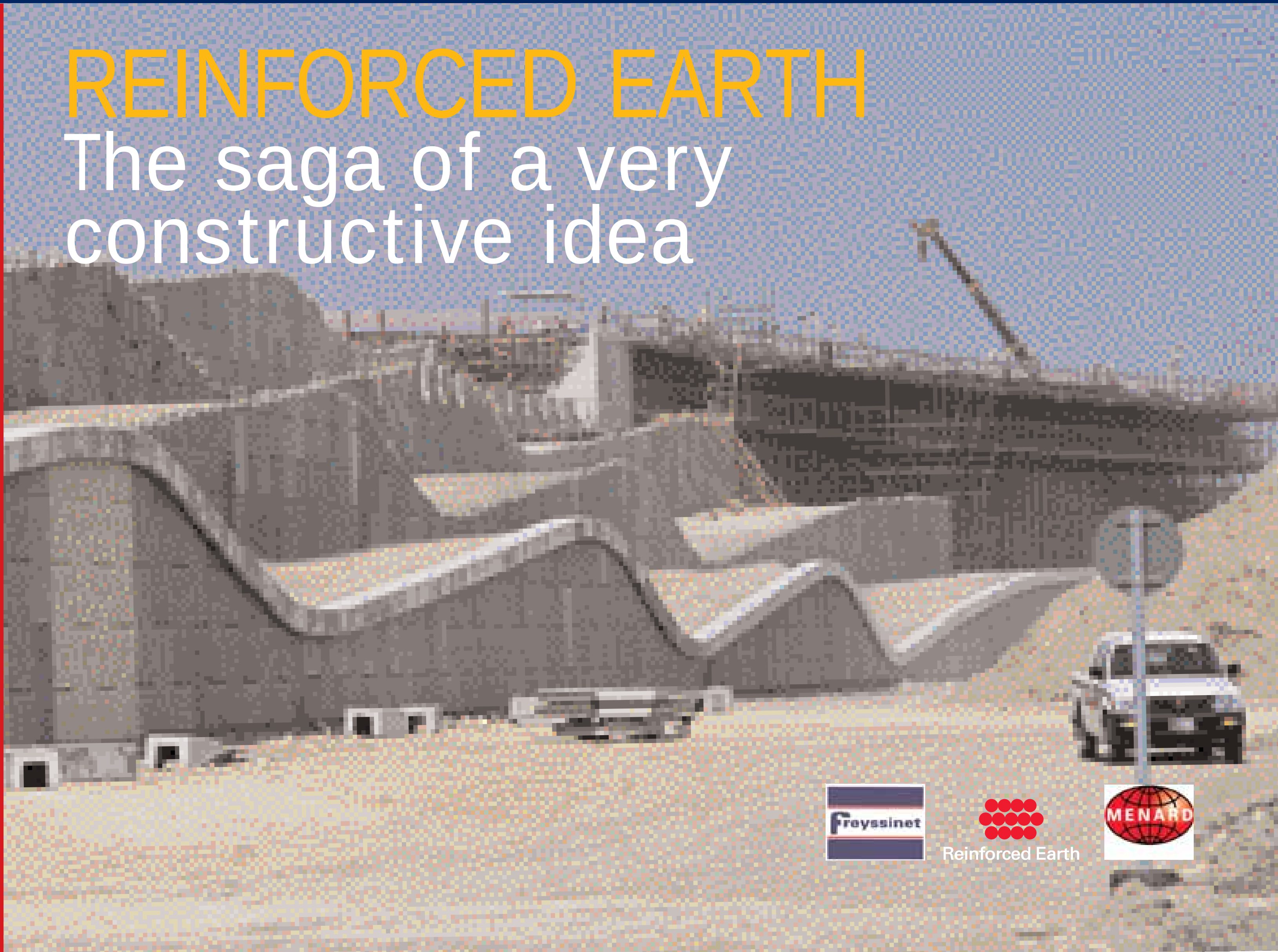
FOCUS THREE ACQUISITIONS TO REINFORCE THE GROUP'S OFFER

REALIZATIONS PONT A.B. RAVENEL JR: TWO FIRSTS IN THE NEW WOLD

HISTORY DYNAMIC COMPACTION: A PRINCIPLE CONSOLIDATED BY INNOVATION

N° 221 First half 2005

REINFORCED EARTH
The saga of a very constructive idea



Freyssinet

Reinforced Earth

MENARD

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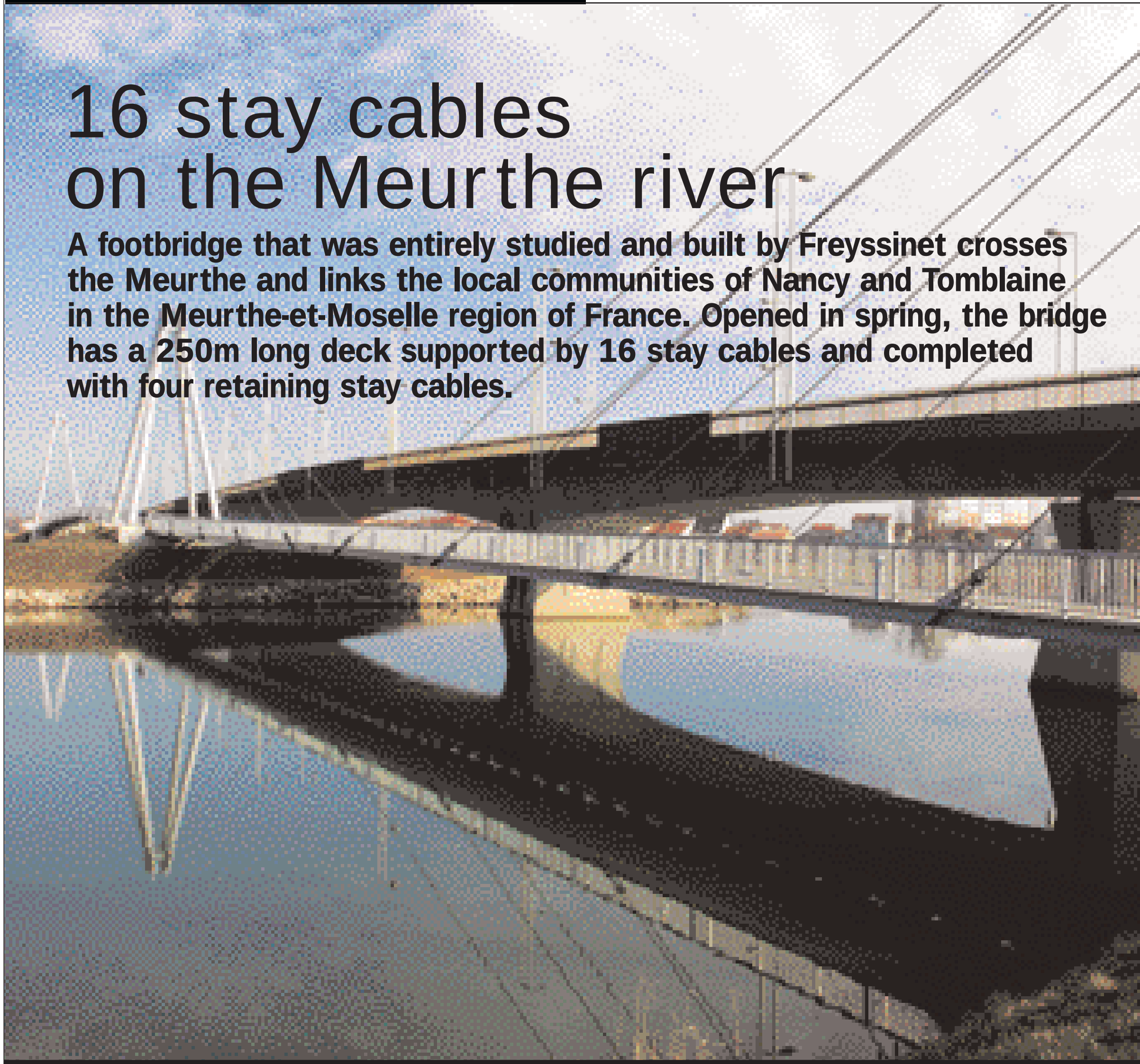
16 stay cables on the Meurthe river



A footbridge that was entirely studied and built by Freyssinet crosses the Meurthe and links the local communities of Nancy and Tomblaine in the Meurthe-et-Moselle region of France. Opened in spring, the bridge has a 250m long deck supported by 16 stay cables and completed with four retaining stay cables.

Inspired walls

In the United States, Reinforced Earth has created a set of tiered Reinforced Earth walls to retain small reliefs along a national highway that is being extended to the north of Santa Fe. Preferred by the New Mexico Department of Transportation to one long single wall, this configuration proposed as an alternative has undergone careful architectural thought and each structure is decorated with inspired motifs of fauna or Indian art of the region design of each structure in our design offices at Hornsby, the building of these elements at Lithgow or in other factories, and then their delivery to the site."

Award

During its convention held in Tampa (USA) last November, the American Segmental Bridge Institute (ASBI) gave its 2004 Award to Jean-Philippe Fuzier for "outstanding career contributions to construction technology for segmental and cable-stayed concrete bridges". Now a consultant, Jean-Philippe Fuzier was Scientific Director of the Freyssinet Group from 1993 to 2002.

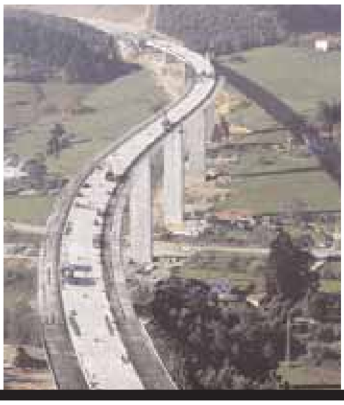
A wall on the line

At Telegraph Bay, in the south of Hong Kong island, considerable work has been carried out in order to build a road that leads to Cyberport, a new IT and new technology business park. After designing the road, Reco HK has just completed building a 25.5 m high two-tier Reinforced Earth with 13 m backfill surcharge. "The eight months that it took to complete this project were very challenging", confides Norman Lee, project manager at Reco HK, "because we had to work under trying environmental conditions (proximity to the road restricted us to using short reinforcements, and created difficulties in implementing logistic resources) without compromising architectural aesthetics."

The pathway in the sky

Freyssinet has just finished building a 34 m long suspended footbridge in the Mafate natural amphitheatre on Reunion island. To build this structure on a section of the island that is isolated, with no road infrastructures, all the site materials had to be brought in by helicopter.

New methods across the Pyrenees



In north-east Spain, the Cantabrian highway goes along a viaduct 848 m long between Vegarrozadas and Soto del Barco. Built by Necso, this structure is made up of ten 74 m spans and two 50 m end spans. Its deck is made up of a box girder that was cast in situ and is 11 m wide with a constant height of 3.75 m, post-tensioned (582 t of steel). Two precast 8 m abutments were fixed on both sides with 736 Freyssibar prestressing bars, 40 mm in diameter, with an average length of 10 m. Supplied and installed by Freyssinet SA, this new method (see s&s no. 219) was used for the first time in Spain.

Strong foundation for wastewater treatment plant

After three months of work, Ménard Soltraitement has completed the soil improvement work for the future San Martin de la Vega wastewater treatment plant, one of the largest in the region of Madrid (Spain). The loamy-sand soil was not dense enough for the foundation of the structure, and consequently Ménard Soltraitement's teams had to treat 130,000 m² of soil by dynamic compaction. To complete the site within the deadlines, three dynamic compaction teams were required, using masses of 15 to 20 tonnes.

Homage

Jean Muller died on 17 March at the age of 80. A graduate of the prestigious Ecole Centrale, he joined Stup (Technical company for using prestressing techniques, which later became Freyssinet International in 1976) in 1947. After heading the New York branch of Freyssinet Company Inc. from 1951 to 1955, he went on to become the technical director and then research director of Campenon Bernard. At the same time, he founded the offices of Figg and Muller in 1978 and Jean Muller International (JMI) in 1986. As of 1988, Jean Muller continued his career with Scetauroute (today Egis). Freyssinet offers its most sincere condolences to his family and loved ones.

10 800 square metres of Reinforced Earth on the Westlink M7

Currently the largest motorway project in Australia, the Westlink M7, to be opened at the end of 2006, will link the outskirts west of Sydney to existing motorway networks. Launched as a BOT project and assigned to the AbiGroup-Leighton (ALJV) joint-venture, this project aims at building 40 km of roadway, 17 interchanges, 38 overhead crossings and underpasses and 146 bridges. The Australian subsidiary of the Group, Reinforced Earth, has obtained a contract to design and build 10,800 m² of Reinforced Earth wall on more than 18 structures.
Ronel Suthers, marketing co-ordinator of Reinforced Earth comments: "Our challenge has been to master the co-ordination of the design of each structure in our design offices at Hornsby, the manufacture of elements at Lithgow or in other factories, and then their delivery on site."

Strengthening in Jamaica

In Kingston, Jamaica, Ménard Soltraitement is strengthening the land carved out of the mangrove to build a dual three-lane superhighway. Called Highway 2000, this new 6-kilometre stretch will double the size of the existing road in 2006 to ease the traffic in the harbour area. To consolidate the highly compressible land in the short time available, Ménard Soltraitement is installing 1.5 million metres of vertical drains and more than 130,000 metres of controlled-modulus columns (CMC).

Renovation at the top

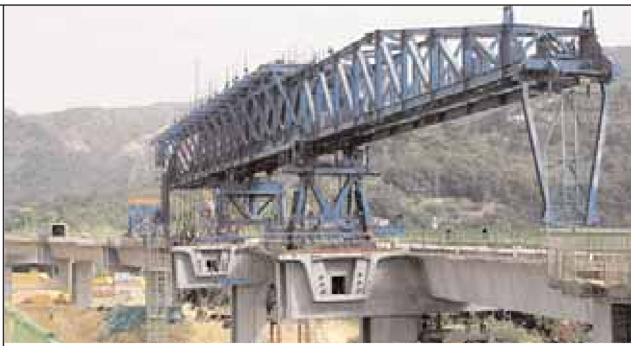
In January this year, Freyssinet took part in renovating the upper platform of the La Gacholle lighthouse, a 19.56 m high structure on land that was built in 1882 in what is today the national park of Camargue (France). Once the damaged areas were repaired with limestone to resemble the original state, a coating of flexible epoxy was applied to the platform to improve its watertightness.

South Africa Resa wins bid for record contract

The South African Reinforced Earth subsidiary recently signed a contract (the biggest concluded since it's inception in 1975) for the design and supply of retaining walls for the Mbabane Bypass, a 12 km section of freeway bypassing Mbabane, the capital of Swaziland. Construction of the freeway began in October 2004 and is planned for completion in March 2006. The project comprises the construction of 14 retaining walls (5,500 m²); 12 true abutments and 4 mixed abutments (5,000 m²) and; the creation of 4 massive tiered fills, each more than 30 m high. All structures will be clad with a plain TerraClass facing. The total face area is 36,000 m² and the total length of 45 * 5mm high

Water protection barrier

In Australia, near the Sydney airport, Austress Freyssinet has built a wall on the banks of the Tempe public landfill. This wall is 18 m deep, 1,360 metres long and is made of bentonite. It was built to prevent leachates from the landfills from contaminating the water in the adjoining canal. The excavation was done using a special crane imported from the United States. Austress Freyssinet has also installed a control device and a system for draining leachates into a purification station.



A testimonial bridge in Hong Kong

In China, Freyssinet has been awarded a contract for the operations of heavy lifting, supply and installation of stay cables, and spherical and pot bearings for the Shenzhen Western Corridor bridge, currently under construction. This new 3.8-kilometre long cable-stayed road-bridge which is a dual three-lane, will be the fourth link between Hong Kong and China. Erected on the Hong Kong side, the inclined asymmetrical pylon of the structure will be supporting two sets of 13 stay cables (300 t). While construction on this project has just started, Freyssinet Asia has finished installing the 113 spans of the Deep Bay double viaduct not far away. Responsible for precasting and installing these elements, Freyssinet Asia is also in charge of designing the 2 launching trusses (photo above) as well as implementing the preload, bearings and expansion joints.

Freyssinet gives a helping hand in tsunami disaster-stricken areas

In India, as everywhere in South Asia, work has begun to rebuild the areas devastated by the December 26th tidal wave. Freyssinet International is working on the site of the nuclear power station plant of Kudankulam in the south of the country (see s&s no. 217), and has made a donation to the neighbouring communities. This donation was handed over at the plant in early January by S. K. Agrawal, Director of Construction, and will be used to purchase land and build houses.

European first in Finland

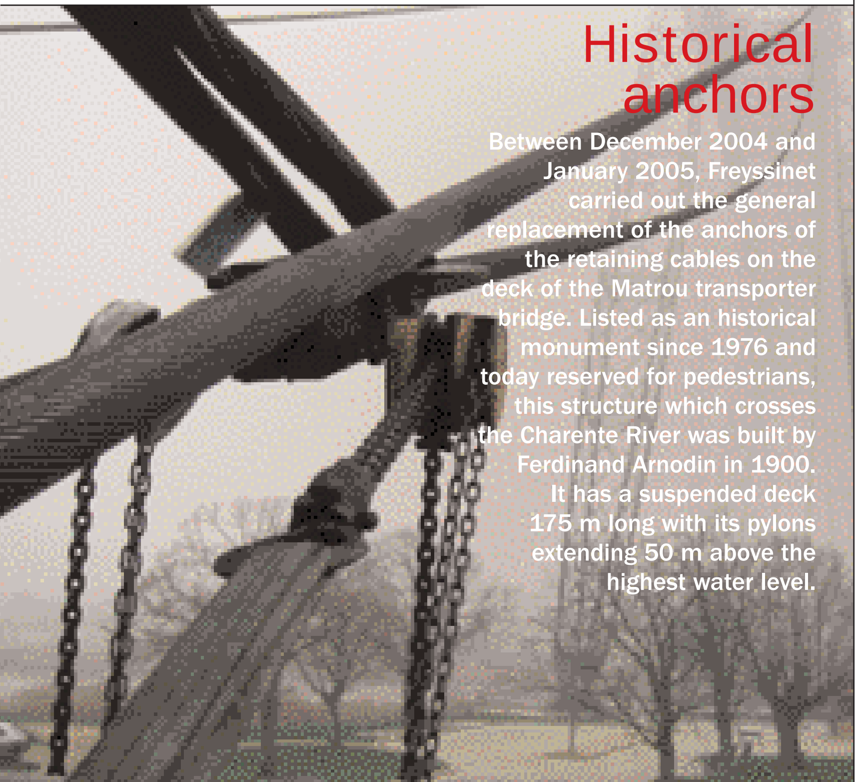
A member of the consortium responsible for building the first EPR (European Pressure Reactor) nuclear reactor on the Olkiluoto site in Finland together with Siemens, the Areva Group has entrusted the supply and implementation of the prestressing of the protective shield to Freyssinet's Structures division. After the Tianwan nuclear power plant (China), this will be the third protective shield that uses Freyssinet 55C15 prestressing anchors.

23,711m² of post-tensioned concrete slabs

Freyssinet Singapore has taken part in designing and laying 23,711 m² of post-tensioned concrete floors for the headquarters of the computer services company Infineon Asia Pacific. The structure is made up of two oval-shaped buildings slightly out of line with each other, linked together by footbridges on the third, fifth, seventh and ninth floors.

Tunnels on the runway

In order to widen the runway at Melilla airport, a Spanish coastal town to the north-east of Morocco, Tierra Armada Spain manufactured and supplied 4,000 square metres of retaining wall facing as well as arches needed for building the two tunnels. The first structure (179 m) will be assembled above a spring of water and the second (202 m) above a road. All the arches as well as the cladding were made by Tierra Armada then stored in a precast yard next to the airport.



Historical anchors

Between December 2004 and January 2005, Freyssinet carried out the general replacement of the anchors of the retaining cables on the deck of the Matrou transporter bridge. Listed as an historical monument since 1976 and today reserved for pedestrians, this structure which crosses the Charente River was built by Ferdinand Arnodin in 1900. It has a suspended deck 175 m long with its pylons extending 50 m above the highest water level.

Stamped on delivery

On January 3rd this year, a few weeks after the viaduct of Millau was opened to the public, the French Post Office (La Poste) confirmed the structure's vocation as a vehicle of exchange and communication by printing a stamp with its picture on it. The stamp costs €0.50 and was designed by Sarah Lazarevic.

Strengthened to the top

Freyssinet carried out repairs and strengthening works on a 70 m high reinforced concrete tower in the cement factory of Jbel Oust in Tunisia.
During the 10 months of the project, 350 m² of Carbon Fibre Fabric (TFC) and 80 metal saddles were installed, with 35 m² of shotcrete also sprayed at a height of over 50 m high without ever disrupting factory production.

Resisting the cold

Selected by the STTS group (Saipem-Technigaz-Tecnimont-Sofregaz), Freyssinet will supply and install the horizontal and vertical prestressings for two liquefied natural gas (LNG) tanks built in Chengdu (China).
Before it won this outsourcing contract, Freyssinet's prestressing system had successfully passed cryogenic resistance tests. 1,230 t of strands will be laid between now and December 2005.

The great wall of Seydhisfjördhur

During the second half of 2004 in Iceland, the land of the midnight sun, Reinforced Earth - Freyssinet's British subsidiary, built two TerraTrel retaining walls of 6,600 m^2. Erected for the communities of Seydhisfjördhur (photo) in the west of the country and Isafjördhur in the north-east, these two structures do not foreshadow future road building projects but rather revive the age-old function of walls in this region: protecting men from avalanches.

By taking over Hebetec, JMB Méthodes and Salvarem at the beginning of 2005, Freyssinet is completing and enhancing its market proposal. Presentation and explanations by Bruno Dupety, Group Chairman and CEO.

Three acquisitions to reinforce the Group's offer

Soils & Structures. **- The year 2005 began for Freyssinet in the spirit of external growth with the integration of three companies. Can you tell us about them?**

Bruno Dupety. – The first of the three to join us was Hebetec on 25th October 2004. It is a company with 23 employees, based in Hindelbank near Berne, in the German-speaking part of Switzerland.
It specialises in lifting, lowering and displacing of heavy loads. When it was created in 1995, it worked exclusively on cables. In ten years, it has grown in by leaps and bounds: its turnover has jumped from €700,000 to €4 million. Today it is a company that has operations worldwide. We actually came into contact with each other through one of our Asian subsidiaries. Focusing on its core business, Hebetec has developed other skills related to the building of temporary steel frames, which are sometimes required in lifting operations. It has developed a revolutionary sliding process called the Air Pad Sliding System (APS) for the naval industry. Based on the use of jacks and the air pad principle, this system was recently used in South Korea to launch giant methane tankers that had been built on-shore. This process which now eliminates the need for dry docks, is set for a promising future!
Lastly, to create a first link between civil engineering and Freyssinet, I must point out that it was a team from Hebetec that lowered the temporary portals for the bridge cap of the Millau viaduct 250 m (170 tonnes) in September and October 2004.
In a field closer to us, we took over JMB Méthodes and its patents for "deck shifting under railways" during the same period. This process makes it possible to erect bridges over railway tracks overnight! We didn't have to travel all around the world to find out about Salvarem: until December 31st, it was part of VINCI Construction Grands Projets. Created in 1979 under the name Radiacontrôle and specialising in the sanitisation of ionised environments, it was acquired by EMCC in 1990 and then by Campenon Bernard in 1993. It has been integrated into the Structures Division of Freyssinet, and is today a wholly-owned subsidiary of the Group. It has a workforce of about 150 people, spread over the three sites in Beaumont-Hague (Normandy), Saclay (Paris region) and Pierrelatte (south-east France) working for the four major companies of the French nuclear industry, CEA, Cogema, Andra and Framatome, specialising in three areas – radioprotection, sanitisation and dismantling in ionising environments.
In 2004, it posted a turnover of €10 million. It has a very strong technical culture and is solidly established in a specialised field, which is the dominant characteristic of the

companies in our group. Salvarem has created innovative tools and methods for sanitisation and decontamination, and has won renown for the dismantling of the Monts d'Arrée and Brennilis (Finistère) power plants as well as the CEA's Triton nuclear reactor in Fontenay-aux-Roses (Paris region).

What are your objectives in taking over these companies?
Our civil engineering operations often involve the lifting of heavy loads, either to position permanent structures or structural components or for temporary displacements during repair or maintenance operations. This expertise, which used to be provided by Freyssinet, was lacking in our structure. Instead of redeveloping it, which would have meant training people and purchasing equipment, we preferred to seize the opportunity of this acquisition which takes us immediately to the forefront of this market. Furthermore, Hebetec has provided us with openings into countries like Germany, Switzerland and Austria, where traditionally we are not greatly represented.
Our activities will be organized in 3 ways: Hebetec will continue its activities with its own clients; it will work either as a partner or as a subcontractor of Freyssinet's entities and subsidiaries; it will lease out equipment to companies of the Group that have maintained their lifting expertise, I'm thinking naturally of Freyssinet France. The takeover of JMB Méthodes will reinforce the advantage gained by the acquisition of Hebetec and should position us on a niche market. The integration of Salvarem, just like that of Hebetec, is aimed at extending and enhancing what we currently offer. However, in this case, it is a question of completing expertise that the Group has had for over twenty years through the NTS (Nuclear Special Works) Division located in Marseilles. For many years Freyssinet was active in the nuclear sector through the supply and installation of prestressing for many nuclear reactor containments. It later developed a structure maintenance offer and has recently taken on the sanitisation and decontamination of the gutters of the auxiliary buildings of power plants, in particular for EDF. In a market where there are no major dismantling operations as yet, it is only by pooling together our forces and working in synergy that we can optimise our commercial penetration and position ourselves more effectively on medium-sized projects, where our objective is to gradually step up our operations.

The Air Pad Sliding system (APS) developed by Hebetec uses jacks and air pads to launch boats that are built on dry docks.

With its three businesses, radioprotection, sanitisation and dismantling in ionising environments, Salvarem rounds up Freyssinet's nuclear offering.

"External growth" is another way of saying "growth" pure and simple. So how is 2005 shaping up for Freyssinet in this respect?
In the first quarter of 2005, Freyssinet recorded an 11% increase in consolidated turnover compared to 2004. Most of the countries in which we operate experienced growth, confirming our subsidiaries' strong market positioning.
Our objective remains focused on "doing better and more everywhere instead of doing everything everywhere". As a result, our performance continues to improve, allowing us to consider further acquisitions in our specialised lines of business. ■

THE SAGA OF A VERY

Forty years after it was invented, the Reinforced Earth technology is used on the five continents and is an example of the benefits that can be reaped by authentic innovations. These benefits still hold a lot of promise, since the technology is highly appreciated by architects and has many convincing environmental advantages.

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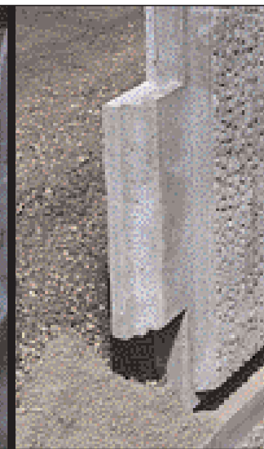

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IT ALL BEGAN LIKE A GAME, when he built a sandcastle on the beach in Saint-Tropez, as was explaining generally Henri Vidal, a highway engineer and architect. But the sand kept on falling off and this led to the idea of reinforcing the construction with pine needles. That is how the general principle of Reinforced Earth came about. Has legend been mixed up with reality? Maybe not exactly, but the hypothesis of the brain wave is not at all surprising in a group like Freyssinet, whose three businesses were founded by famous and prolific inventors. "To sum up", explains Philippe Héry, Director of the Soils division of the Freyssinet group, "Reinforced Earth consists in reinforcing a backfill with reinforcements strips that were originally made of metal. The reinforced structure then becomes its own support and its outer facing is covered with a surface made of precast elements. This technique does not have the disadvantages of concrete walls that are traditionally cast in situ (limited height, unsuitability for average soil conditions, high cost), but also has many advantages. It is flexible, able to support differential settlements, can be adapted to urban areas, where there is a limited covered surface, and is earthquake tolerant. In addition to these technical advantages, Reinforced Earth has demonstrated its architectural resources by giving rise to a very diverse range of surfaces (see p. 12) and its environmental integration potential. Today, it is also very much in phase with the principles of sustainability. "A year after he filed a patent in 1963, Henri Vidal received an order for an initial structure, the wall in Pragnères near Luz-Saint-Sauveur (Hautes-Pyrénées, France) and then produced many structures for the railway company, SNCF. In 1968, he created a company called La Terre Armée that dealt with the development of road and motorway projects and the business rapidly took off and rapidly with branches springing up abroad. It soon created subsidiaries in the

"The Reinforced Earth technology has the advantage of being flexible. It can bear differential settlements and is adapted to urban areas."

CONSTRUCTIVE IDEA

Prefabricated facing scales (1,3), metal or synthetic reinforcements (4,7), backfill material (4,6,7,8): the components of the technology place Reinforced Earth halfway between geotechnics and structures. After they have been laid, they form a composite material that is durable, effective and able to adapt to the most complex configurations.

United States (1977) and Spain (1972). In 1974, licenses were acquired by Sumitomo and Kawasho, that merged with NKK Trading in 2004 to become JFE Shoji, in Japan, which is a high earthquake prone country. At the same time, the company, which had become a group under the name Terre Armée Internationale (TAI), continued to carry out research and developed reinforcements with a very high adherence and consolidated its positions by filing a large number of patents. 1976 was a first symbolic milestone because it was the year that 100,000 square metres of Reinforced Earth were produced and cruted worldwide. Three years later, in 1979, the company established its reputation with the publication, by the roads and road traffic division, of *Ouvrages en Terre armée, recommandations et règles de l'art* (Reinforced earth structures, recommendations and good practices). At that time, Reinforced Earth was hailed as one of the most important innovations of the civil engineering industry. A quarter of a century later, the page was turned as the first patents entered the public domain. However, the process has found its place: it reached the million square metre mark of annual production in 1993, and, in 2004, only five years after TAI was taken over by Freyssinet, it reached the two million square metre mark. Philippe Héry continues his review: "In terms of the number of square metres built, it is North America (and mainly Florida and Texas) that come first with 33%, followed by Asia with 32% (20% of which comes from Japan), Europe (18%), Latin America (8%), and the rest split between Australia, Africa and the Middle East. In fact, he underlines, the fact that owing to its ability to offer steel reinforcement strips designed by Reinforced Earth as well as the synthetic reinforcement strip system (Freyssisol system) promoted by Freyssinet in the 1990s, Freyssinet can meet all requirements, even on soil with a very high chloride concentration as is the case of port structures or Middle Eastern countries." All over the world, Reinforced Earth is thus recommended and used in applications that range from roads and motorways, railways, bridge abutments, hydraulic installations, train platform walls and industrial sites. "However, the perfect illustration of the success of the technique, is the way in which each country adopts it to suit its needs. This is what we're seeing for example today with the impressive infrastructure programme being carried out in India where the use of Reinforced Earth is being increasingly used, as well as in Europe and the United States where projects have to comply with very stringent architectural and environmental standards."

« "Our package is engineering, supply of components and aid in set-up." »

PHILIPPE HÉRY, SOILS DIVISION MANAGER

Driven by the entities of five divisions out of the seven divisions created to enhance Freyssinet's expertise worldwide, Reinforced Earth, nevertheless stands out in the Group by its relative absence in its construction sites. This important ▸▸


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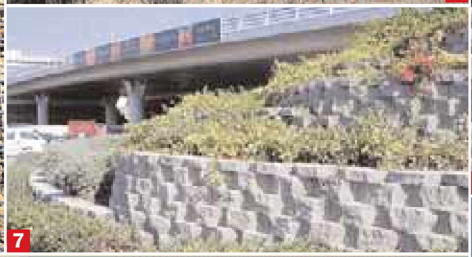
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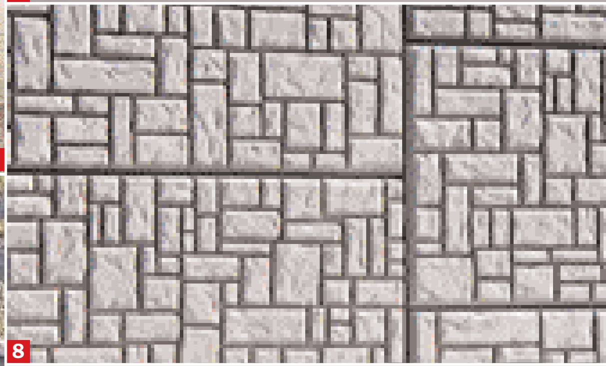
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►► specificity is explained by the fact that in France, for example, the company has less than fifteen employees based at the Freyssinet site in Vélizy. “We are selling a system, not a product, stresses Philippe Héry. Our “package” consists in the engineering, the supply of components – cladding panels and reinforcements – and technical support during assembly, which is a service aspect that is very important for us.” This characteristic is naturally expressed in the large proportion of engineers among our employees. The Technical Division that works on the Reinforced Earth segment, is known as SoilTech, and is based in Nozay. It is a relatively light structure with four engineers, one of which is a consultant. The team draws on the global Reinforced Earth network, which enables it to multiply its action.

SoilTech, a technical guarantee

“All the companies are technically and commercially accountable, explains Nicolas Freitag, an engineer at SoilTech. This means that most of them have a design and engineering department dedicated

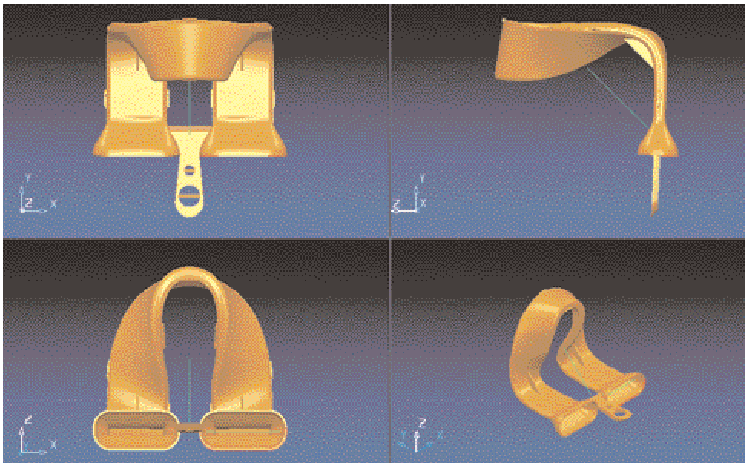
Whether it is the scale shape, its composition, surface appearance, "graphic treatment or plant decoration, the technique offers a particularly rich palette of "renderings".
1 TerraPlus Retaining wall on the State Highway 4 in Maryland (United States).
2 Architectural Freyssisol surfaces near Raon-l'Étape (France).
3 Details of a pattern adorning the Reinforced Earth wall on State Highway 114 in Texas (United States).
4 Architectural pattern of the Childress wall in Texas, with TerraPlus surfaces (United States).
5 5 de Mayo Interchange, Lower California (Mexico).
6 TerraTrel Access ramp near Faulquemont (France).
7 TerraBlock Retaining wall in Dubai (United Arab Emirates).
8 Architectural facings of a retaining wall on State Highway 45 in Texas (United States).
9 Retaining wall with specific panels on motorway A29 in Vallon-de-Rogerville between the Le Havre and Saint- Saens (France).
10 Architectural TerraClass wall in the port of Boulogne-sur-Mer (France).

"At the heart of Reinforced Earth's research and development, SoilTech works to bring quality to the business."

Roger Bloomfield : «Sharing global expertise»

"The main asset of the Reinforced Earth technology is its ability to change and adapt, which enables it to meet the needs of new markets, reckons Roger Bloomfield, CEO of RECo in the United States. As the main Reinforced Earth company, we put a lot into this strategy and work very closely with SoilTech. We hope in this way that we will be helping the Group to cope with the future requirements. We apply the same approach when we take part in in-house meetings such as the recent ones in Dubai or in Boston last year. Actually, we should probably revamp our slogan "global expertise, local experience", because today, our practices are more along the lines of "global sharing of local expertise". All the major Reinforced Earth entities are today pursuing an active R&D policy; and the challenge is to share these areas of expertise among all the companies."

to their operational activities (action plans) and to meet requests for specific applications received from architects. SoilTech is the heart of Reinforced Earth's research and development system. It focuses on the technical aspect to "bring quality to the business", which is a major criterion for our clients. Its tasks also include assisting the other companies. In everyday terms, this function, which represents more than half of its business, is proof of the dynamism and diversity of technical communications between entities, whether it is a matter of finding a set of references for sea walls in the archives to finalise a call for tender by the subsidiary in the United Arab Emirates, of looking for the solution to a design problem in South Korea in the network, which has about thirty experts worldwide, or delivering a solution to a young company. Research and development is a more highly strategic activity that is just as linked to communications. SoilTech therefore carries out continuous intelligence, analyses lost contracts with a fine-tooth comb, observes the competition, takes part in the work of the International Geosynthetic Society (IGS), to "get a feel of needs and identify any shortcomings". When you listen to Nicolas Freitag, the SoilTech attitude for this mission can be summed up in a single word that is in line with the original idea: innovation. "In spite of 40 years of history, we can do a lot to improve the original ingenious idea using new materials and numerical digital analyses that will enable us to optimise the performance and safety of structures and inventions that may not have generated applications but are the source of new ideas!" Among the research focuses that have recently given rise to the filing of patents, we must point out the development by SoilTech, in collaboration with Terre Armée BV (Netherlands) and Terre Armée SNC (France), of the Omega connection, a system for anchoring the synthetic reinforcements strips ►►



Developed by the Reinforced Earth research and development division, the Omega connexion is an anchoring system for synthetic reinforcements that is cast directly into the panel during the prefabrication stage.

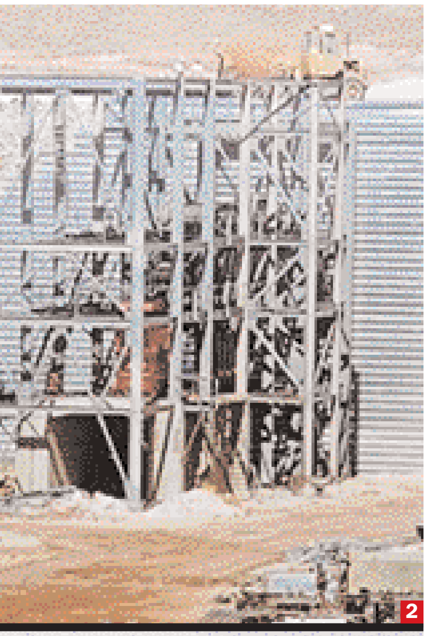
1 The reduced implementation time of the technique makes it a favourite in road, motorway and railway structures (photo 1: South Korea).
2 Because it meets industrial site layout requirements, Reinforced Earth has been used to erect over one hundred dump walls worldwide (photo 2: Australia). Its flexibility also makes it ideal for circular retaining structures like the Muskeg foam tanks in Canada (photo 3).
4 The qualities of Reinforced Earth in land applications are repeated in sea or river constructions, with a strong resistance to the stress of floods or swells. In Den Bosch (The Netherlands), for example, mixed TerraClass and TerraTrel walls retain houses in this way.

►► into the panel during the prefabrication. It is a fine example of how SoilTech is able to combine its expertise with the research carried out in the network. SoilTech has validated a similar connection, called C, also began designed in the United States and completed in the United Arab Emirates, using its profound knowledge of standards, its mastery of test procedures and statistic interpretation.
“This way of operating has proved to be right, Martin Van Den Berg, manager of Terre Armée BV assures us. This is because, for over thirty years, it has enabled us to share all the questions handled by SoilTech with about forty Reinforced Earth subsidiaries worldwide and to solve their clients’ problems.” SoilTech will be focusing on a new subject in the near future. It is directly connected with the emergence of sustainable development and concerns the increasing use of excavated material on sites and no doubt material obtained from demolition (recycled concrete, road-drilling material) as backfill. “Our services include material specifications, explains Nicolas Freitag, and when one of the companies can no longer obtain supplies of conforming new material that meets specifications, we have to provide them with information on how to use or treat (chalk treated with cement, loam treated with lime) to ensure that mechanical or chemical problems do not deteriorate the reinforcements strips.”

Together with the design team

Provide solutions and anticipate needs: this sums up the entire philosophy of the sales team of the French subsidiary, based in Vélizy, under the motto “global expertise, local experience”. It has divided France into three operating areas: the South-West, under Pierre Sery, the director of Terre Armée SNC, the North with David Brancaz, and the South-East plus the export regions, under Alain Tigoulet. “Project man-

The philosophy of Reinforced Earth’s sales teams focuses on delivering solutions and anticipating needs.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agers and the design firms Egis, Setec, Ingerop and Arcadis, who are in charge of the research and design on the capital investment projects of public bodies (local councils, regional authorities, Government) are our privileged contacts, he explains, because when a retaining structure is planned, we get together to define a solution, either on our own initiative or because we have been consulted. We're also in touch with a large number of consultancies, including architectural firms specialiszed in civil engineering structures, and design offices (between 30 and 50) with whom we devote nearly half our time." This upstream work normally provides between 10 and 12 months of work before the project, most of the time represented by flagship projects such as the recent bearing and retaining structures of the viaduct of the RN 202 bis trunk road at Saint-Laurent-du-Var, the Soumont wall near Lodève, on the A75, in the Hérault region (over 30 m high and covering an area of 10,000 m^2), the five structures of the Mussidan-Périgueux section of the A89 motorway (12,000 m^2), or the 30,000 m^2 project being executed on the A51 motorway at Monestier de Clermont, in the Isère region. The sales managers spend the rest of their time between preparing answers to invitations to tender and project follow-up. On one hand, they work with the design department headed by Eric Lucas, who provides them with the survey statements they need to cost evaluate their project costs and assists them in resolving geotechnical problems, and Alain Gorce, the construction manager, in relation with the two panel prefabrication companies; and on the other hand they work with the beneficiaries of the construction works – earthwork contractors and structural works contractors to put the final touches to the geometry of the structures, which may have changed significantly since the initial studies, and to define the actual implementation conditions (nature and granulometry of backfills, soil content, etc.).

For Alain Tigoulet, the list of tasks should include contacts with the Freyssinet network, which supports the development of exports. "An increasing number of projects are being executed outside France, he concludes. We have sites in the former French territories and we're also answering tenders in the Balkans, Romania, Russia, Greece, North Africa, Senegal, and even as far as Swaziland, an area managed by Reinforced Earth Pty Ltd (South Africa)." ■

INTERVIEW

Charles Lavigne: "Sculpting nature"

A specialist of civil engineering structures, architect Charles Lavigne has not only linked his name to the Normandy bridge, but also designed many Reinforced Earth structures, in particular on the RN 202 bis trunk road, the Mussidan-Périgueux section of the A89 motorway and the A75 with the Soumont wall.

Reinforced Earth is considered a major innovation of the public works sector of the 1970s. Do you agree with this?
Indeed I do, and for two reasons. From a technical viewpoint, Reinforced Earth opened up new horizons by making it possible to erect very high walls with vertical faces that are very easy to install even in places that are difficult to access. From an architectural viewpoint, its large surface scales, which conjure up the cyclopean walls of Central America or Egypt, have given a new dimension to retaining walls. We can sum up by saying that Reinforced Earth makes it possible to remodel landscapes and sculpt nature.

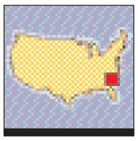
What was the first structure on which you used Reinforced Earth for the first time?
It was in the late 1970s on the A40 Nantua-Bellegarde motorway (Ain), at a spot where roads were on a mountain slope and were separated. The creation of a Reinforced Earth wall using the excavated material of the higher road made it possible to support the downhill road, which was not supported by anything. For this structure, we designed an exclusive model with scales that came in four varieties. This obliged us to make a pattern layout of 150,000 m^2 of Reinforced Earth, but in winter the walls are adorned with stalactites and this gives a superb effect.

What are the architectural resources used in the process? How do you use them?
To create light and shadow effects that emphasise or diminish the presence of structures in the landscape, we can work with an entire range of surface skins (stony appearance, smooth appearance, etc.) and their organisation. On the Soumont wall, the creation of a staggered effect recalls the presence of a stream. On the Brest ring road, I used tile-covered facings. Some architects use coloured concrete. TerraTrel is a solution that is very popular at the moment, because you can see the material. And because it can be used on slopes, we can plant vegetation on it, which rapidly gives a very natural facing in no time at all.

What is your vision of the creative potential of Reinforced Earth ?
The technique has already demonstrated what it can do. It can find new applications in all the places where we want to create large movements of earth, give a landscape a facelift or requalify a site. I'm thinking of the use that could be made of Reinforced Earth cords for landfills, the possible reclaiming of disused quarries to return them to the environment. I think that is what we managed to do on the A40, and even more recently in the La Maurienne valley, where we used Reinforced Earth to requalify the mountain bedrock that had been disfigured by many brown fields.

STRUCTURES / **ARTHUR RAVENEL JR BRIDGE**

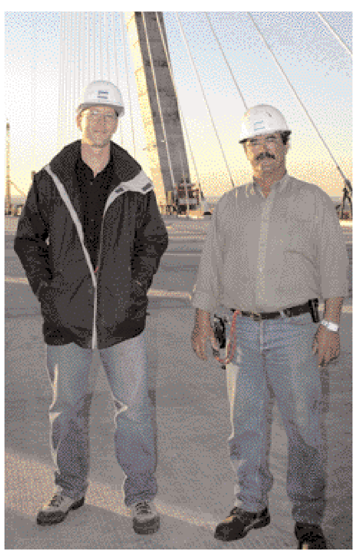
Two firsts in the New World



With the record of the longest central span in North America, the bridge on the Cooper river is also the first contract to supply and install stay cables that the company has signed in the United States.

BETWEEN CHARLESTON AND MOUNT PLEASANT in South Carolina, two steel bridges on the coast form the crossing of Highway 17 over the mouth of the Cooper River. These two bridges, one of which was built in 1928 and the other in 1968 have long ceased to meet traffic needs or comply with safety standards. They will soon be replaced by the Arthur Ravenel Jr bridge that is nearly completed. This new bridge is remarkable for many reasons: with a length of 4,023 m, 900 of which are cable-stayed, and with a central span of 472 m, it will beat the record of the longest cable-stayed span in North America (which had been held by the Alex Fraser bridge in Vancouver). The Ravenel bridge is supported by 128 stays that have been entirely supplied, installed and tensioned by Freyssinet. That is the other remarkable new feature of this bridge. "It is the first time that we have won a contract to build stay cables in the United States, explains Olivier Forget, project manager for Freyssinet. We only provided technical support on the Leonard P. Zakim Bunker Hill bridge in Boston and the Bill Emerson bridge in Cape Girardeau."

With its vast experience, the very international Freyssinet team erected a pair of stay cables per pylon and per week, despite the five hurricanes that hit the region in September" notes Olivier Forget with pride. In addition to the supply and installation of the stay cables, the special climatic conditions of the region led the State Department of Transportation to ask Freyssinet to carry out a series of studies and analyses of the stay cable vibrations and provide a damping system. During the construction works, we had to erect "high-wind" stability cables to stabilise the structure when the average wind speed exceeded 75 km/h for an hour. Thanks to a system made up nails and a counterweight, the deck swung like a pendulum during the hurricanes.



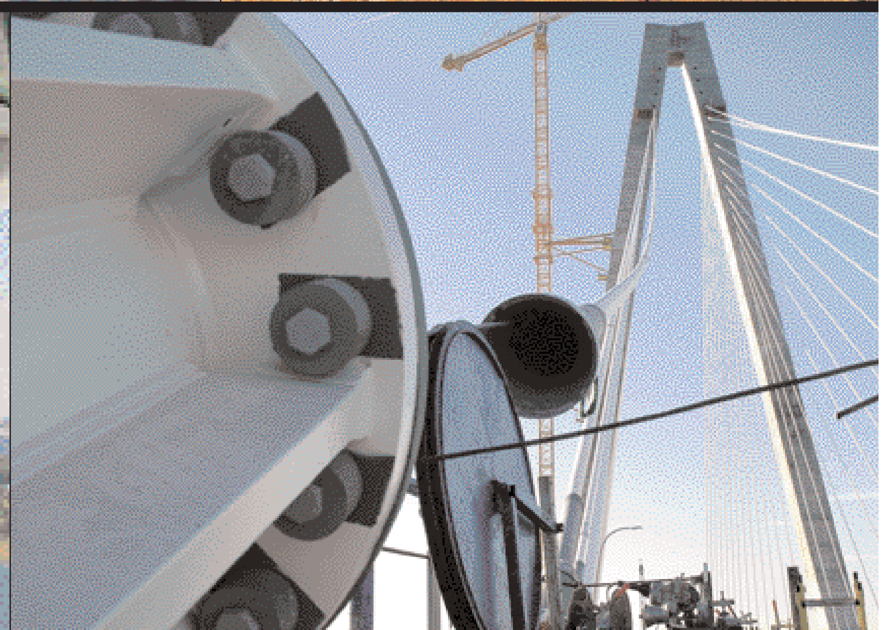
Olivier Forget, project manager for Freyssinet , and José Lopes, Freyssinet field manager.

Special dampers

Freyssinet's international team, made up of ten different nationalities, arrived on the site in early January 2004. It finished laying the cable stays on 11 February 2005 and is currently installing the 112 internal hydraulic dampers, which includes 28 double dampers (specially designed for the structure) and 16 external dampers that will be installed on cables in excess of 250 metres. At the same time, it is carrying out the geometrical adjustments to the bridge. "We will complete our participation at the end of May with damping tests on the cable stays in collaboration with Advitam, our sister company specialised in the maintenance and surveillance of structures", concludes Olivier Forget. ■

PARTICIPANTS

- **Owner:** South Carolina Department of Transportation
- **Consulting Engineer:** TY Lin.
- **Design engineer:** Parsons Brinkeroff – Buckland Taylor.
- **Main Contractor:** JV Skanska-Tide Water-HBG Flatiron.
- **Specialised Contractor:** Freyssinet.

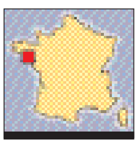


With its diamond-shaped towers, the profile of the new bridge will strike all passers-by. “The structure must have a light longitudinal profile for aesthetic reasons and to withstand earthquakes, but it must at the same time be heavy enough for the hurricanes that are common in the region“, explains Olivier Forget. In addition to its visible and modern design, the bridge was built using other Freyssinet expertise: to control stay cable vibrations to the bridge construction the structure was stabilised with 112 internal hydraulic dampers and 16 external dampers.

STRUCTURES / **BONO BRIDGE**

Rebirth of a hundred and fifty year-old structure

Closed for two years because of its bad state, the Bono suspension bridge (Morbihan, France) has been given a new lease on life thanks to Freyssinet's bridge renovation expertise.



NESTLED AT THE BOTTOM OF THE MORBIHAN GULF NEAR AURAY, the small Breton village of Le Bono (2,000 inhabitants) is located on the banks of the Le Sal River. The only link between the two banks was an "old" suspension bridge, 100 m long, built in 1840. The structure had two trusses made up of 3 load-bearing cables on which 62 hangers were attached. On each bank, loop-shaped retaining cables were supported by the walls of the U-shaped tunnels dug into the granite bedrock. The bridge deck was composed of road bearers and metal pieces. It held a platform made of hardwood organised into a Hungarian point and laid on ledger strips. The bridge, which was designed at the period when carts were in use, was strengthened in 1870 and again in 1925 to enable it to bear the weight of vehicles of up to 12 tonnes. Lateral stiffening girders forming hand-rails were added to the bridge deck at this time.

Whipped by spray

Located in a sea environment and fully exposed to the vagaries of the weather and sea spray, the metal structure had deteriorated over the years, leading the local authorities to close the bridge to vehicles in 1995 and to pedestrians at the beginning of 2003. Although it no longer held strategic interest for the local inhabitants, since the construction of another bridge further upstream that enabled motorists to cross the Sal, the old bridge remained entrenched in the local memory and inhabitants remained very attached to it.

After the Bono mayor's office managed to have the bridge listed on the supplementary inventory of historical monuments in 1997, it decided to save the structure from collapse and mobilised to collect the funds needed to restore the bridge and reopen it to strollers. A call for tender was launched in June 2004 for sand blasting and general painting, the replacement or repair of certain metal parts and the complete replacement of the hardwood platform. Freyssinet, who won the contract, proposed another solution consisting of complete reconstruction of the bridge deck using a galvanised structure, and changing of the twelve suspension cables.

Evacuation by flotation

The team came to the site in October 2004 and immediately set to work to dismantle the suspended span. "We "oxy-cut" the bridge deck into 6 m sections, which we took down using linear winches and transported away by flotation", explains Ronan Bohéas, an engi-

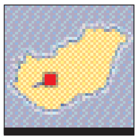
neer at Freyssinet. In early December, we removed the old suspension cables. We collected the metal sockets and gave them to the cable supplier for socketing. Freyssinet also carried out additional works, such as rehabilitation of the access spans and anchor chambers. After the new suspension cables were delivered, reconstruction of the bridge deck began at the beginning of February. "The process was the opposite of the dismantling process, i.e., the sections were brought by sea", continues Ronan Bohéas. After the bridge was completely rebuilt, at the end of April 2005, and the suspension adjusted by equipressure, the old bridge was inaugurated and reopened with the pomp and festivities worthy of this land of the "forban", a two-mast rowboat. ■

PARTICIPANTS

- **Owner:** town of Bono.
- **Consulting Engineer:** Morbihan public works department.
- **Engineering Consulting Company:** Sogreah Best (Pontivy – 56).
- **Main Contractor:** Freyssinet.

SOILS/**M7 MOTORWAY**

Consolidating the lakefront



In Hungary, where work is underway to extend the M7 motorway, Ménard Soltraitement has mobilised a team to carry out soil consolidation over 400,000 square metres alongside Lake Balaton.

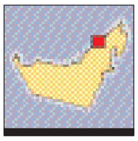
SINCE IT JOINED THE EUROPEAN UNION, Hungary has launched a massive programme to modernise its infrastructure, in particular to bring its motorways in line with the European network and to relieve the isolation of some of its regions. For example the extension works on the M7 motorway, which connects Budapest to Sófiok, to the north-east of Lake Balaton, will, provide a link with Croatia, which is only 120 km away. The contract for the work on the section running alongside the lake was awarded to the Hungarian company Vegyepszer. Part of the works is on a ten-kilometre stretch where there is thick marshy land (up to 5 m thick in some places) that requires ground improvement . Of the various solutions proposed, the main contractor chose the one offered by Ménard Soltraitement consisting of dynamic replacement. This was judged to be the most efficient, the most competitive and the fastest to implement.

Dynamic replacement and controlled-modulus columns

"We have to make sure that the backfill is stable and reduce differential settlements to a minimum on the motorway segment", explains Gilles Costa, in charge of the work being carried out by Ménard Soltraitement. To cut down on pedestrian traffic on bridges under construction, we have created an original solution that combines dynamic replacement sections and controlled-modulus columns (CMC). "At each end of the structures, the first 15 m of motorway were treated with CMC and the next 15 m with dynamic replacement with preloading. The current section of the motorway had been traditionally treated with dynamic replacement." To implement the project and realize about 400,000 m² of dynamic replacement within the tight deadline (the works were completed at the end of April), Ménard Soltraitement mobilised five cranes doing double shifts. At the same time, a team of sounders and a pressure meter team carried out preliminary tests, work inspection and installation of monitoring instruments that were mainly interstitial pressure sensors. "Of the thirty odd people who took part in this project, nearly a third were recruited and trained locally" Gilles Costa adds. ■

PARTICIPANTS

- **Owner:** Hungary Motorway
- **Main Contractor:** Vegyepszer.
- **Specialised Contractor:** Ménard Soltraitement



STRUCTURES/**JEBEL ALI SILOS**

Strengthening at the top and bottom

In Dubai (United Arab Emirates), additional prestressing made it possible to increase the capacity of a sugar silo and enabled Ménard Soltraitement to enhance its soil consolidation expertise.

The silo's capacity has been increased with the 117 additional prestressing that strengthen it over a height of 16 m.

THE SHARP GROWTH OF THE SUGAR refining industry in the Jebel Ali free port franc in Dubai, has led the port authorities to develop their storage facilities. In 2004, it launched the construction of a new 900,000-tonne silo. However, this capacity turned out to be insufficient even before the project was completed. The only solution that could be envisaged without demolishing and rebuilding the silo was to raise the concrete skin roof by 20 to 25 m.

"To prevent any excess structural overall weight, the project consulting engineer recommended that an external additional prestressing be added", explains Khalil Doghri, manager of the Freyssinet Gulf agency. "That is how we managed to win the contract in mid-May 2004 after a bidding process." To strengthen the structure, the Freyssinet teams installed 117 cables with a height of 16 m around the sailor silo (this represented 80 t of steel). Each ring was made up of 4 strands each 138 m long connected by 468 X anchors, enclosed in single HDPE ducts injected with cement grout.

55 m high of sugar

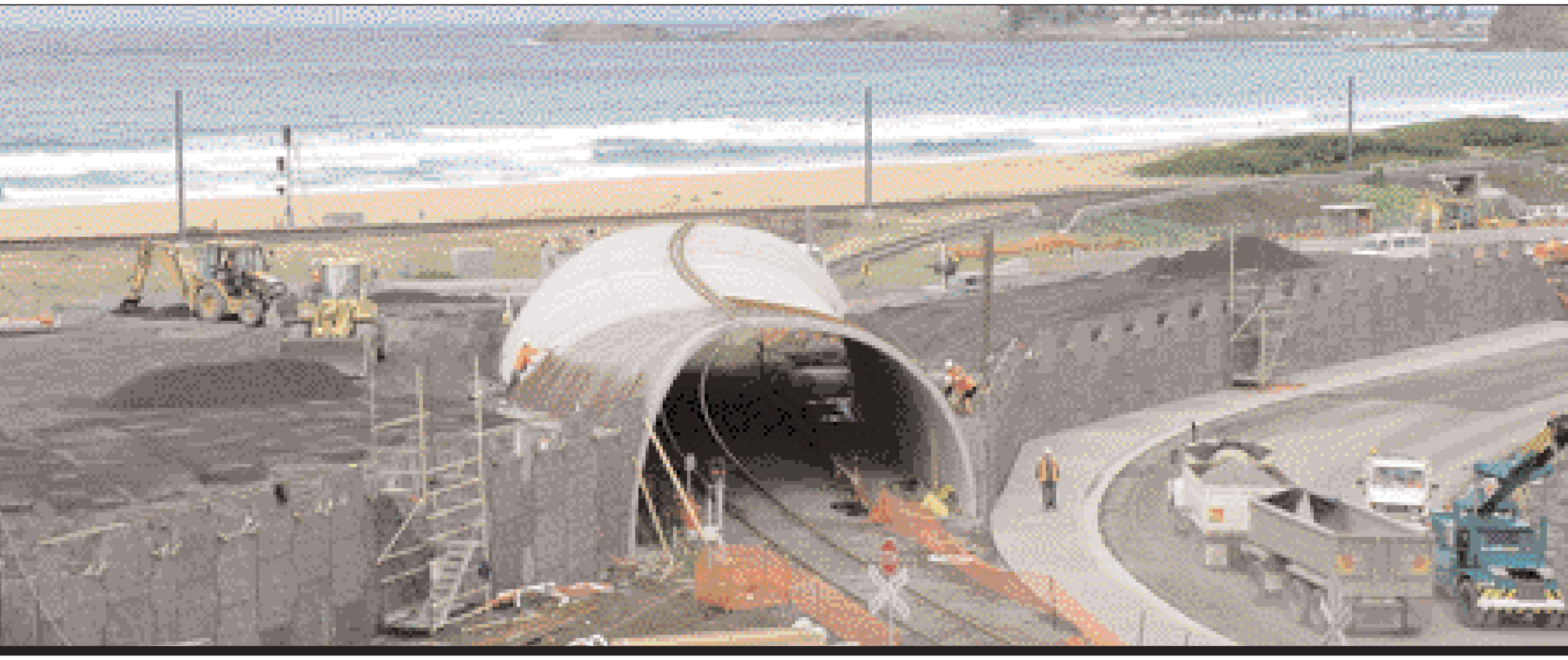
"When we were informed that new silos were to be built during our work, we immediately presented Ménard Soltraitement to the owner for a foundation soil improvement solution for the new structures", continues Khalil Doghri.

Changing the initial solution by sinking piles sunk into the sandy and silt-laden soil, which is a very common technique in the United Arab Emirates, Ménard Soltraitement proposed the installation of dynamic replacement that will enable the soil to bear the weight of the silo at full load, which is the equivalent of a height of 55m of sugar… and carried off the contract. "The calculations were complicated", confides Dominique Jullienne, in charge of Ménard Soltraitement's business in the Emirates, "and we had to take into account all the loading and reloading of heavy loads on time".

There were some other parameters such as the dynamic loads caused by the rubbing of sugar on the walls of the silo. Finally, the solution proposed by Ménard Soltraitement consisted in the combination of the company's technical expertise: dynamic replacement, partial replacement (piling of aggregate into soils of weak consistency) and the dynamic compaction of soils. This treatment was applied under the silo skin roof, which resulted in the uniform sagging of the silo slabs. "All the studies were validated by modelling the behaviour of the slab laid on consolidated land and using a Ménard pressuremeter", concludes Cyril Plomteux, an engineer at Ménard Soltraitement. ■

Group synergy

Located in the same premises in Dubai, Freyssinet Gulf, Ménard Soltraitement and Reinforced Earth offer very complementary services to their clients. Employees of the three companies are constantly in touch and propose comprehensive and responsive solutions, thanks to a very diverse range of services. In addition to the construction of the new silos of the Jebel Ali free port, the synergies developed over the last five years have resulted in other common projects such as the Townsville sugar terminal in Australia (see S&S no.° 217).



SOILS/ **NORTH KIAMA BYPASS ROAD**

Building a Tunnel

The Reinforced Earth Company in Australia combined retaining walls with precast concrete TechSpan arches to make it possible for a new access highway in North Kiama (Australia) to cross a railway.

Located two hours by car to the south of Sydney, North Kiama (New South Wales), with its beaches, mountains with lush vegetation and picturesque blow hole (cavity in the rocks on the seashore from which water spurts to heights of 60 m under pressure from waves), is a choice destination for Australians. For many years, cars could only take one road to get there: a single-lane, winding road called the Princes Highway. Construction of a new road was proposed in 1990, but it was not until 1997 that construction of this completely new, double-lane highway commenced.

The second phase of construction, that began in November 2003, involved the Australian Reinforced Earth subsidiary designing and supplying a a covered railroad span (64 m long and 12 m wide) composed of TechSpan elements and Reinforced Earth supported access ramps to replace the previous Princes Highway grade crossing.

“The plans for the tunnel were drawn up using 3D-design software. This made it possible to optimize the design allowing for the complex geometry created by the horizontally and vertically curved rail track and the acute-angled retaining walls supporting the highly skewed bypass road. This was probably the main challenge of the project,” states Michiel Knol, Reinforced Earth engineer and project manager. These 3D simulations made it possible to validate tunnel height and, especially, to adjust the ends of the covered span that were turned towards the interior. It was necessary to build 86 TechSpan® arch elements: 70 with classic width, 7 with reduced width and 9 specially tapered elements.

In the final configuration, the road will cross over the covered span. For this, 2400 m^2 of retaining walls are under construction and will be used for the access ramps on each side. “We were forced to find a technical solution to allow the general contractor to build the walls without interrupting traffic on the Princes Highway running alongside the structure on the ocean side,” explains Michiel Knol. The construction timeline called for the retaining walls on the land side to be built first. On the other side, temporary TerraTrel mesh walls (1270 m^2) have been built to stabilize the backfill and avoid run over into the road. “Once traffic can be moved to the land side, we'll be able to complete construction of the covered span and retaining walls on the ocean side,” specifies Michiel Knol.

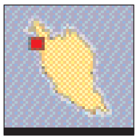
“Technically and architecturally speaking, this is an interesting project that uses three of our construction systems to achieve global aesthetic harmony,” concludes Graham Linn, Reinforced Earth warehouse manager. He also highlights the attention brought to the facing panels, in particular, that were specially precast to blend harmoniously with the landscape. ■

PARTICIPANTS

- **Owner:** Roads & Traffic Authority of NSW.
- **General Contractor:** John Holland Pty Ltd.
- **Design and Supply:** Reinforced Earth Company Australia

STRUCTURES/**SUNGAI PRAI BRIDGE**

A lesson of know-how



In Butterworth (Malaysia), the construction of the Sungai Prai Bridge has mobilised the Freyssinet teams, who are working on construction methods as well as the supply and erecting of stay cables.

ON THE WEST COAST OF THE MALAYSIAN peninsula, less than 100 km from the Thai border, the town of Butterworth opposite the island of Penang, is one of the country's largest port complexes. It is also the heart of a region undergoing fast industrial and urban growth, where the 12.1 km Butterworth Outer Ring Road project was launched as a concession in 1997 to connect the Jalan Baru interchange in the south of the town and the Sungai Dua interchange in the north, running alongside the port and the ferry terminal. In addition to the many road improvement works, the project also includes the construction of a dual three-lane 2.85 km bridge (28.8 m wide) that will cross the Prai River, as well as a "trumpet" interchange that will come back to the port.

The structure is made up of two approach bridges each comprising ten and eleven 50 m spans, a 185 m cable-stayed span and three access ramps. "We began by developing a 120 m overhead self-launching truss weighing 850 tonnes (see picture above), that enabled us to lay the segments composed of 21 spans on each side of the cable-stayed bridge", explains Fernand de Melo in charge of the methods unit at the Freyssinet Technical Division. This will enable us to install "triple-box" spans that are 14 m wide and weighing 1,500 t, composed of precast segments supplied from the bridge deck that has already been laid. These are the central cores of the deck, and they will receive the precast lateral cantilevers, lowered by cranes and then held in place with prestressed cables.

Multiple cantilevers

"The laying method used for the main span of the cable-stayed bridge is not very different", continues Fernand de Melo. The precast segments (also three-box girders) are brought from the deck, which has already been built and installed by cantilever construction method, from each pylon by a portal frame fixed to the deck. The stay cables are installed and tensioned at two-segment intervals. As on the rest of bridge, the lateral cantilevers are fixed with prestressing bars to the main structure. The segment of two of the access ramps are laid using a second self-launching truss that erects the 29 spans, two sections of which will span the railway tracks. The third spiral access ramp is built on a falsework.

The Prai river crossing will be on a 485 m cable-stayed bridge with a central span of 185 m. The deck is supported by 112 twin stay cables, protected by white HDPE ducts and supported at the two pylons (39m high) by single-tube deviation saddles. "The first stay cable was launched on 9th October 2004, and we have 9 months to finish laying the cables", explains Pascal Martin-Daguet the Freyssinet engineer in charge of the site. Before the structure is opened to traffic in January 2006, to ease Butterworth's traffic woes, Freyssinet will also have supplied and laid bearings and expansion joints. ■

PARTICIPANTS

- **Owner:** Lingkaran Luar Butterworth Sdn Bhd (concession company).
- **Main Contractor and design office:** Perunding Jurutera DAH Sdn Bhd (Dar Al-Handasah).
- **Main Contractor:** IJM-Züblin Joint-Venture.
- **Specialised Contractor:** Freyssinet PSC – Freyssinet APTO Joint-Venture.

Supported by 112 twin cable stays, the bridge that will cross the Prai river is 485 m long.

STRUCTURES/**ESSO GLEN COMPLEX IN LONDON**

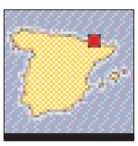
Post-tensioned concrete slabs gain popularity in Great Britain

50,000 m^2 of post-tensioned concrete slabs have been laid in the heart of the City.

IN VICTORIA, CENTRAL LONDON, a group of prestigious office buildings with avant-garde architecture are under construction. The program, known as Esso Glen, is made up of two structures: one 10-storey glass building graced with curves and the other a more classical 6-storey building. "These two buildings represent a total of 50,000 m^2 of post-tensioned concrete slabs. We supplied and installed 320 t of 5S13 and 12K15 strands for this project, as well as temporary prestressing cables (1S15) for the transfer beams," notes Paul Bottomley, Freyssinet Ltd Technical Director. This site, located in the heart of the City district, is a sign of the current growth in the use of prestressing in Great Britain and Ireland.

Architects, contractors and clients have compared the architectural advantages and profitability of the process for all types of residential or professional real estate projects," explains Patrick Nagle, Managing Director of Freyssinet Ltd.

The company has seen a sharp increase in its projects: Freyssinet is currently working on the Beetham Hilton, a 47-storey building under consturction in Manchester; the Bridgewater Place, a 33-storey real estate complex in Leeds; the AMS House, a smaller project near London; and the Ballincollig Var Parks in Cork in Ireland. ■



STRUCTURES/**THE GUIPÚZCOA GREEN BELT**

Carbon strengthening on the waterway

THE SPANISH BASQUE COUNTRY has an unequalled supply of hydraulic resources and experiences a drought each year. To find a solution to this problem, the Guipúzcoa authorities have adopted a special plan based mainly on the interconnection of the dams of the towns of Ibai-Eder and Barrendiola, in the Urola valley.

To connect the two structures, separated by a distance of 16 km, the routing that was chosen was that of a mining railway track that was no longer in use. The project could therefore use existing infrastructures (11 bridges and 19 tunnels), which nevertheless had to be strengthen and renovated. The authorities decided to kill two birds with one stone by creating a "green belt" for cyclists and strollers all along the route. "We won the contract to rehabilitate 8 concrete bridges, made up of between 1 and 3 isostatic spans, making a total of 17 spans since each structure had a double-T deck that was 3.6 m wide", explains Pedro Sancho, head of Freyssinet's Basque country office branch.

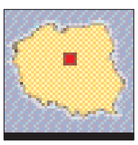
The solution recommended by the design team was based on strengthening the bending resistance, so each bridge girder could withstand a tension stress of 380 kN in its centre, and on strengthening the shear force. The technical solution developed by the technical department of Freyssinet's Iberian-American division in Madrid, is based on the use of composite materials. The Freyssinet teams strengthened all the structures with 2,864 m of carbon fibre laminates (LFC) and 122.70 m of carbon fibre fabric (TFC) of a width of 300 mm. In the places where the concrete was damaged, the steels were first passivated using epoxy resin agents. After that, we applied high-performance thixotropic mortar and acrylic paint to protect against carbonation. ■

PARTICIPANTS

- **Owner:** Diputación Foral de Gipuzkoa.
- **Main Contractor:** Mariezcurrena.
- **Specialised Contractor:** Freyssinet S.A.

STRUCTURES / **PLOCK BRIDGE**

Three records over the vistula



Construction of the Plock Bridge (Poland), the biggest cable-stayed structure in the country, began in July 2002 and will be completed in the middle of 2005.

The structure will be 1,200 m long including 585 m of access spans and a 615 m main cable-stayed bridge with a 375 m central span. The dimensions of this bridge built over the Vistula to the northwest of Warsaw do not at all reflect the importance of this project, combining the expertise of Freyssinet International and Freyssinet Polska which is breaking all sorts of records in Poland.

The main span of the bridge is the longest ever built in the country and the access spans, composed of metal, required the largest lifting operations ever performed. Assembled on the ground in segments 60 m-long and 27 m-wide, these 600 t pieces were put into place using a lifting frame and hydraulic jacks and were then welded together.

In the second phase of construction, two 64 m-high I pylons were installed and the deck of the central span was built by the successive cantilever construction method. The segments were brought to the site by the river and were then lifted into place using a SL 230 system of cables and hydraulic jacks with a total capacity of 4710 kN. While the segments were being placed, Freyssinet teams installed the 56 stay cables. The twin stay cables are disposed on a central plane, "a configuration that brought elegance and grace to the structure," says Krzysztof Berger, General Manager. Depending on their length, which varied from 38 to 188 m, the cables are composed of bundles of 47 to 84 strands enclosed in Mediterranean-blue, HDPE (high density polyethylene) ducts.

In association with supply and installation of the stay cables and heavy lifting, Freyssinet was also involved in a third part of the project: installation of bearings and use of out-of-specifications systems. In this respect, the structure also broke a third record. Of the 56 bearings installed on the piers, two spherical bearings, one placed on each of the end piers, were of extraordinary dimensions and had a nominal capacity of 110 mN.

Freyssinet drew upon its expertise in heavy lifting, cable staying and structural fitting to work on Poland's largest cable-stayed structure.

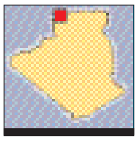
"The final stay cable was installed in January 2005 and the deck will be closed when the temperature reaches +5°C. Construction that never interrupted river traffic, will now continue until June 2005 with a reduced team responsible for final adjustments" concludes Andrzej Berger, the engineer.

PARTICIPANTS

- **Owner:** town of Plock and General Road and Highway Department (GDDKiA).
- **Engineering Consulting Company:** Pontprojekt Gdansk.
- **General Contractor:** Mosty Lodz S.A. and Mosty Plock - consortium
- **Consulting Engineer:** ZBM Inwestor Zastepczy Sp z.o.o.
- **Specialised Contractor:** Freyssinet Polska, in association with Freyssinet International.

SOILS & STRUCTURES/**THE ORAN INTERCHANGE**

Openings for the construction team



By joining forces to propose a more competitive variant for the Oran interchange in Algeria, Freyssinet has provided Reinforced Earth with the opportunity to carry out its first retaining structure in ten years.

IN 2001, A PERIOD DURING WHICH ALGERIA massively renovated its infrastructure, the public works department of the Wilaya of Oran, the country's second largest city, decided to build an interchange in the eastern part of the city. The project included several civil engineering structures, one of which was a curved bridge with a radius of 56 m. "In 2002, the Algerian public enterprise Seror-Tlemcen, who had won the contract, contacted us for assistance in designing the bridge", explains Habib Merabet, head of Freyssinet's North African operations. In the beginning, the project consisted in building a slab-bridge on trusses with access ramps comprising a hollow abutment in reinforced concrete. "However, given the height of the bridge piers and the rugged landform, this technical solution quickly proved to be expensive, continues Habib Merabet. It would also have meant closing down traffic on a very busy stretch below the bridge."

An intrados on a spiral

To make up for these disadvantages, Freyssinet and Terre Armée SNC proposed a variant to the solution consisting in launching the precast slab-bridge and the replacement of the hollow abutment with a 18 m high Freyssisol retaining wall. Structural studies for the bridge kicked off in 2003. "We redefined the geometry of the structure with an intrados with a spiral to make it easy to shift", explains Stéphane Faure, the engineer in charge of the works. The final solution was a slab-bridge with a constant thickness of 1 m, positioned in a circle with an average radius of 56 m. The 123 m bridge has two 17 m end spans and four 22 m central spans. "The whole structure represented more than a quarter circle to shift." remembers Stéphane Faure.

As the superelevation of the bridge varied between 0 to 7% with a downhill longitudinal slope that could be as steep as 7%, Freyssinet opted for a flexible launching system that also had retaining characteristics. On site, work began with the erecting of the piers and creation of a precast area made up of two curved sleeper plates that serve as a rack for the TP200 push rams and bear the weight of the structure. The equipment is completed with a 25 m curved launching, side guides on the piers and slip saddles.

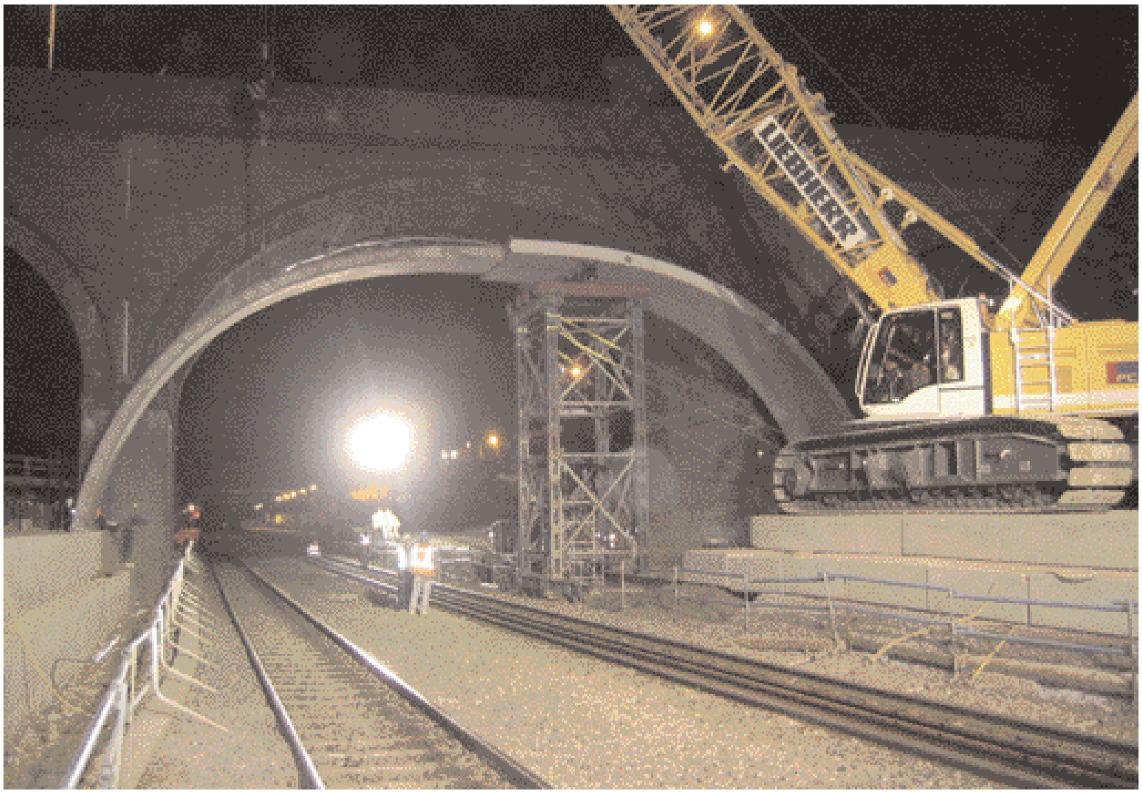
The construction was carried out in four sections that were assembled by a centred prestressing, coupled at the end of each section and made up of sixteen 19C15 cables. After the piers had been erected, Freyssinet fitted the bridge with Tetron and Neoprène pot bearings and expansion joints. It then installed the final continuity prestressing, made up of twelve 19C15 cables. At the same time, Reinforced Earth supplied more than 20 moulds for making 800 Freyssisol panels. This technology, used for the first time in the country by Seror, was used to build the main abutment access ramp to the main abutment (2,500 m^2). The bridge was inaugurated on 24 December 2004. ■

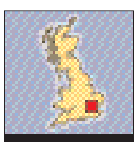
PARTICIPANTS

- ▶ **Owner:** Direction des travaux publics (DTP) de la wilaya d'Oran.
- ▶ **Main contractor :** Seror-Tlemcen.
- ▶ **Design and methods :** Freyssinet.
- ▶ **Specialised Contractor:** Freyssinet and Terre Armée SNC.

STRUCTURES / **GERRARDS CROSS PLATFORM**

A supermarket on the right track





In Gerrards Cross (United Kingdom), there wasn't enough space for a supermarket and a parking lot. With the use of TechSpan arches, both will soon be inaugurated on a platform built over the railroad tracks.

TAKING ADVANTAGE OF THE FOUR HOURS during which railroad traffic comes to a halt, PCE's arch erection teams works on the site in Gerrards Cross, a small town to the northeast of London. Every night, the team, working for main contractor Jackson Civil Engineering, installs 5 of the 343 pieces of the TechSpan arches that will soon form a 320 m-long cut-and-cover tunnel above two railroad tracks. On this structure will be built a platform upon which will rise a supermarket and car park. Is this an original way to make the most of previously-unusable spaces? Not really, according to Jon Cross, the director of Reinforced Earth. He traces this idea back to the early 1960s: "As early as 1962, Norwest Holst, a VINCI subsidiary, executed ground investigation for the scheme."

Now, 35 years later, another VINCI group subsidiary, Reinforced Earth, became involved in the project. In fact, engineering consultant named White Young Green approached the company in 1998 to assist development of a solution using a buried precast segmental arch system: this was the starting point for the Gerrards Cross project. Originally, the preliminary design called for 14 m span arch to cross the existing twin tracks Chiltern Line. "Since then, Jon Cross explains, the final scheme required a much larger 20 m span to allow for any future widening of the railway line up to four tracks."

Safety and environment first

From the outset, safety and the environment have always been the two key criteria guiding this high-impact project. Those living near the site must not be disturbed by work performed at night. "When we won the bid for the contract in 2003, we immediately sought to optimize the arch sections for increased width and to limit the number of pieces needed to be installed", describes Jon Cross. This made it possible to limit the equipment required on the site as much as possible: a 160 t capacity crane was sufficient for installation of the arch pieces that each weighed 23 t."

Installation began on October 10th, 2004 towards the western end of the tunnel. At the western portal, the entrance is formed from a series of truncated arch units tied together with an in-situ concrete ringbeam. The eastern portal comprises full-height precast concrete headwalls flanked by Reinforced Earth TerraClass wingwalls. The span must also pass through the central span of the Packhorse roadway bridge. The continuity of the covered span relies on 9 single piece precast arch units placed on two skew back beams. The entire tunnel structure is founded on auger bored piles.

Construction is planned for completion in the second quarter of 2005 following backfill of the arch with 100,000 m^3 of ground limestone. Then, all that remains is construction of the supermarket that is planned to open at the end of the third quarter. ■

PARTICIPANTS

- **Owner:** Tesco Supermarkets
- **Project Manager:** Gleeds
- **Consulting Engineer:** White Young Green
- **Main Contractor:** Jackson Civil Engineering
- **Arch Construction:** PCE Ltd
- **Specialised Contractor:** Reinforced Earth Company Ltd

A PROTECTIVE CURRENT TO STOP CORROSION

In specialised civil engineering, some professions can be understood at a glance while others require greater insight. This seems to be the case with the team of a British subsidiary of Freyssinet Group, the CCSL Company (Corrosion Control Services Ltd). "The same operations are always used in cathodic protection (see box), declares Ian Spring, technical director of CCSL. Our first task is to connect cables to the concrete reinforcement and to check it's electrical continuity. We can then install an anode that can come in different forms depending on the requirement. We also install monitoring electrodes and connect all these elements to an electrical cabinet." After the current (usually with a voltage of less than 12 V) has been established, treatment follows immediately and CCSL can track performance from its offices in Telford, using remote devices.

Although it is increasingly applied as a preventive treatment for new structures, cathodic protection continues to be used more for repair works, where the deterioration of concrete may come from two main causes: chlorides (when the structure is exposed to a salty atmosphere) or carbonation (development of calcium carbonate due to the transformation of the atmospheric carbon dioxide reducing the pH of the concrete). "Our first task, therefore, is to establish a diagnosis, explains Jim Preston, director of CCSL. We do this either when we are asked to do so directly by a client who has observed a deterioration in a concrete structure, or as a subcontractor when a consultant has already recommended that cathodic protection be carried out. Whatever the operation schedule and the nature of the corrosion, CCSL has a solution in the vast offering that it has managed to develop in less than ten years (the company was created in 1996) not only for the treatment of existing structures, but also for new construction: cathodic protection for reinforced concrete, buildings with steel frames and submerged structures in marine environments such as pipelines, etc.. CCSL works in the four corners of the world (it is currently in the United Kingdom, Ireland, Hong Kong, Croatia and Saudi Arabia) and has thus collected valuable data about structures that have received this type of treatment. This enables it to offer its clients reliable and proven solutions.


1

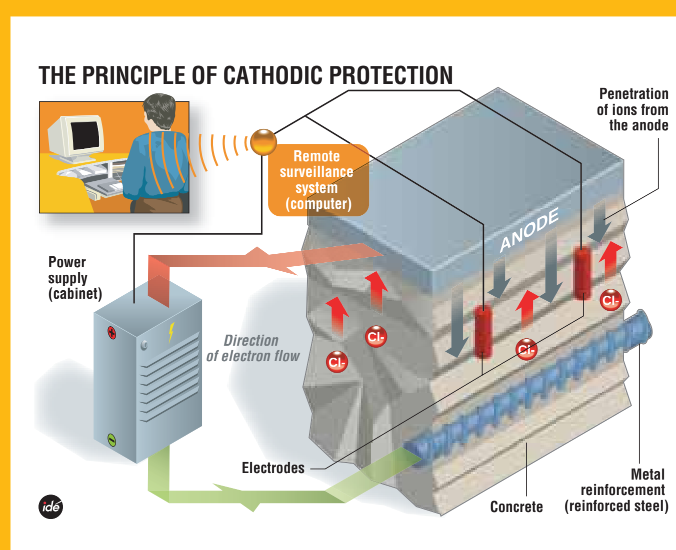

2

Once the titanium anode is installed, the installers make the electric connections.

"Demand for this technique goes as far back as the 1980s, continues Jim Preston, and we can say that it literally exploded at that time. The principle is, however, much older because it began with the work of Humphrey Davy in 1824. We therefore did not invent anything new and only adapted a long-established engineering technique to the problems of our modern materials." ■

An electrolytic process

The environment for steel reinforcement that is provided by good quality concrete is of high alkalinity. Provided this environment is maintained, the steel will remain passive and no corrosion will take place. Corrosion is a process of electrochemical deterioration. The infiltration of impurities into concrete (for example atmospheric carbon dioxide) disrupts the chemical balance and reduces the pH of the material. Chloride ingress to the steel will also result in depassivation. Upon contact with water and oxygen, metal atoms are ripped from the surface, lose electrons and are ionised. The metal becomes polarised, forming one or several macro-batteries on its surface. The resulting electrical field erodes the metal at the anode (pits). Such loss of elements results in what is known as corrosion. To neutralise and stop this process, the metal is transformed into a cathode. This can be accomplished either by running a weak impressed continuous electric current through the metal or by connecting it to a galvanic anode, a different metal that will corrode more readily than iron and create an electron flow that enables to fight the charges to which the reinforcements are submitted: that is cathodic protection using sacrificial anode.



FREYSSINET POLSKA CONFIRMS ITS BREAKTHROUGH

One of the 5 cable-stayed bridges on the A4 motorway.

Successive launching of bridges over the Czerniakowski crossroads in Varsovia.

For six years now, Freyssinet Polska has made a name for itself in Poland thanks to a dynamic and efficient team and by marking each year with an important achievement.

In May 1995, a year after Poland applied for membership to the European Union, Freyssinet International opened a technical information office in Warsaw, under the management of Krzysztof Berger, an engineer of public works. Four years on and after many successes (external prestressing of the Góra Kalwaria bridge, strengthening of the silos in Werbkowice, Brzeg and Bodaczów, etc.), they consolidated their advantage with the creation of the limited liability company Freyssinet Polska SP. Z o.o.

That was how the success story of the 33-employee subsidiary began. "We started off with Freyssinet's traditional areas of expertise, explains Krzysztof Berger, General Manager of Freyssinet Polska since 1999, and we gradually added Reinforced Earth and soil treatment activities to our offering. Consequently, our image has changed considerably and we are now recognised throughout the country as one of the unavoidable players in the specialised civil engineering business." This small subsidiary's reputation is concretely illustrated in prestigious projects that it has carried off in barely 6 years: construction of five cable-stayed bridges over the A4 motorway in 1999; incremental launching of the bridges of the Czerniakowski interchange in Warsaw in 2002; the cable-stayed bridges of Wolin and Poznan in 2003; the Plock bridge on the Visula today (see page 24). In 2003, these successes, and the efforts behind them, were crowned with the Gazela Biznesu prize (Business prize) awarded by the magazine Puls Biznesu to investors, design offices or civil engineering companies for their dynamism, results and commitment to sustainable development.

THE COMPANY IN BRIEF

- **Name:** Freyssinet Polska Sp. z.o.o.
- **Address:** Poland, 05-822 Milanówek, ul. Mala 5, tél./fax: + 48 22 724 43 55/56.
- **2004 Turnover:** 4,5 M€.
- **Number of employees:** 27.
- **General manager:** Krzysztof Berger.

An active support from Freyssinet Belgium

In the Group and in terms of organisation, Freyssinet Polska is attached to the Northern Europe division, which includes the United Kingdom, the Benelux and the Scandinavian countries. "There are a lot of synergies between the various companies within the division, says Krzysztof Berger. In 1999, when the works sites of the A4 motorway began just a few days after the company had been created, we received a lot of support from Freyssinet Belgium, and particularly Claude Mortier who sent several technicians to work with our teams. However, this culture of exchange and support is not limited to the regional level: it continues, for instance with Freyssinet France on the bridges in Plock, Wroclaw, Warszawa and is currently being developed in soils." ■

Headed by par Krzysztof Berger (on the left side) (3), the company is divided into five divisions: the Works division, directed by Andrzej Kandybowicz 3, which is made up of two engineers, Piotr Beczek and Andrzej Berger 2, and three team leaders, Sylwester Ostafinski, Grzegorz Hrynczyszyn and Tomasz Cieplucha; the logistics division with Zofia Krawczyc and Katarzyna Wlódarczyk (9) the Marketing department, with Lucjan Talma (10) and Anna Marjanska (4); the Accounting Division with Pawe_ Skrzypczak and Karolina Wudarczyk (6); the soil improvement business headed by Arkadiusz Franków (5) and composed of an engineer Adam Syzdól (1) and a project designer, Marta Sierocinska (11) for Reinforced Earth activity, Jakub Saloni (7) for Ménard Soltraitement. The company also employs a warehouse manager Dariusz Kwiatkowski (8) and a maintenance mechanic, Krzysztof Szkop.

INNOVATION

THE PARASEISMIC DEVIATOR (PSD)

The stay cables on structures exposed to seismic activities must be protected at the anchors.

The Charilaos Trikoupis Bridge, which is located on the Gulf of Corinth (Greece), one of the main areas for seismic activities on the planet, was built to resist earthquakes that measure 7 on the Richter scale without sustaining damages. In charge of supplying and installing the stay cables, Freyssinet developed a new protection system in collaboration with VINCI Construction Grands Projets to confront this problem.

Prevent bending

"The bridge is in complete suspension", explains Benoît Lecinq, Technical Manager of Freyssinet. "In case of earthquakes, it swings longitudinally by approximately 2m, completely relieving the stay cables of stress or inversely, causing large amounts of over-stressing. The PSD was created to prevent angular breakage of the stay cables when they leave their anchor tubes on the pylons and the deck."

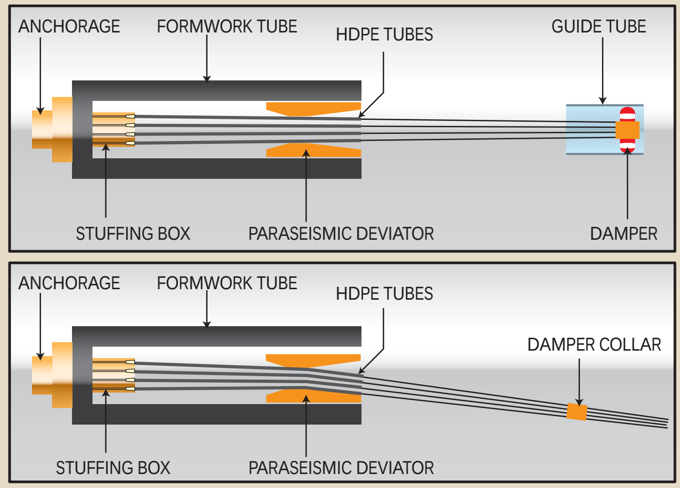
"In the event of an earthquake, the PSD limits the curving imposed on the strands until the stay cable is load is fully eliminated. The combined traction and bending constraints do not exceed the elastic limits of the strands, "and this is the case until an angular deviation of almost 10° occurs", specifies Benoît Lecinq.

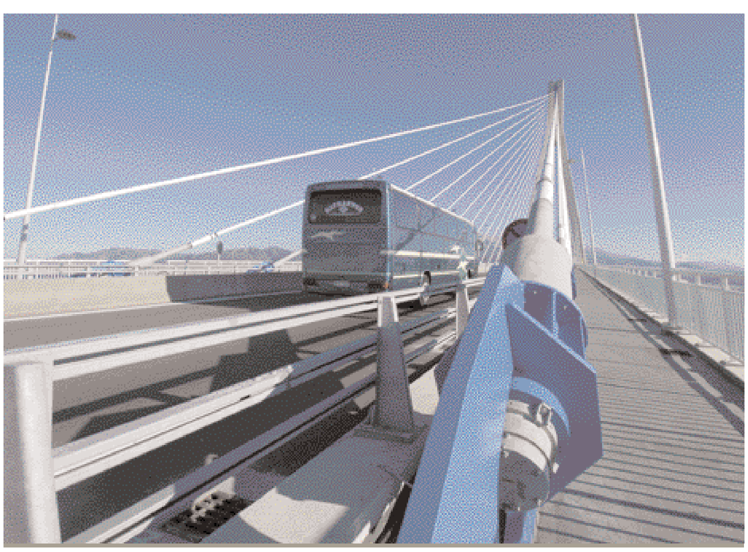
The PSD, which is the result of a close technical collaboration between the technical department teams of Freyssinet and VINCI Construction Grands Projets, passed the lateral load resistance tests at the test division of Freyssinet's Technical department, based in the Group's factory at Chalon-sur-Saône (Saône-et-Loire). "Moreover", stresses Benoît Lecinq, "we had to draw up the technical specifications for the system, made out of polyurethane reinforced with steel tubes to mass-produce the 368 pairs of PSDs that equipped the bridge". This production was closely monitored using a process of numbering with electronic chips buried in the resin thus ensuring complete traceability.

The same thing was done for the installation of the system to make it as flexible as possible. "During the development, we gathered the opinions of users, especially that of David Grattepanche, in charge of installing the stay cables on the bridge", explains Jean-Pierre Messein, engineer of the Freyssinet's Technical Department. With the information obtained, we were able to decide that it was preferable to insert the PSDs into the anchor tubes well before threading the cables." This system also facilitated the task of threading the strands and significantly reduced installation time.

A prestigious application

The 368 stay cables of the Charilaos Trikoupis Bridge measuring between 75 and 292m, benefit from the Freyssinet system: individual anchors, individual anticorrosion protection, individual installation and tensioning (or eventually, re-tensioning). The working end of the cable consists of a parallel beam of 40 to 75 strands, individually protected by galvanisation. A petroleum wax fills the spaces between the wires. Each strand is threaded into a white co-extruded HDPE sheath.





Since the 1930s the Russians had been using a process similar to that of pounding piles, i.e. releasing a mass of one or two tonnes from a height of five to six metres, At the end of the 1960s Louis Ménard, a director of a design office at the time came up with the idea of making the soil denser at great depths by using very high energy waves. He revolutionized this technique by developing new tools that made it possible to go higher and to pound with even more strength to deeply consolidate and solidify large tracts of land.

1970 Louis Ménard patented his process and not long thereafter, obtained his first contract, to solidify a 400 m^2 platform at Bormes-les-Mimosas in the south of France. Menard offered the contractor a solution in which a 10-t mass was released from a height of 10 m with standard crawler-mounted cranes. That was the beginning of dynamic compaction.

1973 The soil solidifying practice at the Cofaz factory in Havre (Seine-Maritime) used five cranes and became the ultimate reference. Louis Ménard became recognised as an entrepreneur. To optimise the performance of the process and to reduce costs, the young company launched a new 16-t mass to be released from a height of 25 m. At the same time, the field of application for the process, until then reserved for sandy soil, was extended to clay land. This was made possible by using a new technique derived from dynamic compaction, dynamic replacement, in which ballast was added to the soil to give it more consistency.

1974 The company was consulted to solidify the offshore soil of Brest harbour, where nuclear submarines were to be repaired. Once again, the engineers revealed their creativity and installed a standard crane with a "chip-cutter" mass of 10 tonnes mounted onto a barge. Accepting challenges that were always more audacious, the sites of Santo Domingo and Los Angeles in 1975 led the company into making its own equipment: tripods capable of releasing 40-t masses from heights of 40 m at a rate of 20 pounds per hour. To lift the mass, a system of 3 m-rise hydraulic jacks were installed. This equipment was efficient, but was too slow and in 1976 the company decided to create a new kind of machine. This machine could be completely dismantled and transported. It could lift a 40-t

DYNAMIC COMPACTION: A PRINCIPLE CONSOLIDATED BY INNOVATION

Dynamic compaction is the first process proposed by Ménard Soltraitement thirty years ago and it is still used for the foundation of buildings and bridges, and to stabilize large surfaces of backfill or loose soil. While the principle of the technique have not changed, installation methods have been modified considerably and are continuously being refined.. Here's an example.

Eben site in Austria.

Offshore consolidation, Ostenfeld (Sweden).

Kansai airport platform in Osaka (Japan).

mass to 25 m and could be operated on solid ground and off-shore because of its two opposing arms. It proved not easy to manage, and was used on only two sites, one of which was in Uddevalla , Sweden.

1977 and 1978 The development continues: Ménard developed a new underwater dynamic compaction system with hydraulic linear winches that could release 40-t masses from a height of 10 m.

The magnitude of this innovation culminated in the solidifying of the platform of Nice airport (1978): a crane transported on 168 wheels and equipped with a 1,500 horsepower winch (7 km of hydraulic hose), capable of lifting a 200-t mass to a height of 20 m (height limit set by the airport authorities) was created and, equipped with a device that adjusted the centre of gravity with each release. “Six months were necessary to set up the crane on the site. A great deal of this period was taken to assemble the mass, comprised of sheets of steel, stacked and fixed with a 600 kg nut that needed to be tightened …with a bulldozer”, recalled Jean-Marie Cognon, Operating manager of the company at the time. The death of Louis Ménard in that same year marked the beginning of a new approach to dynamic compaction, where the use of greater masses and heights was no longer viewed as “the” solution to improve efficiency.

1980/1990 Traditional or non-standard cranes used up to that time gave way to simple but computerized machines used exclusively for dynamic compaction. A winch made up of two perpendicular beams, that lifted a mass of 25 to 30 t to a height of 25 m and a booth, was assembled in only two days instead of the week required for the old systems.

The tripods were only used on two sites, Osaka (Japan) and in Hong Kong, but almost immediately , they wer further developed to lift the mass in one go with an enormous jack (1.4 m^3 of oil).

2004 The technique crossed a further barrier with the implementation of the Mars process (Mass Release System – S&S no. 220) developed by Jean-Claude Morizot, R&D Director of the company: an automatic mass release process of the mass which enabled even heavier loads to be used without losing efficiency previously linked to cable friction (generally 30% to 40%) This innovation produced an optimised energy of compaction. ■

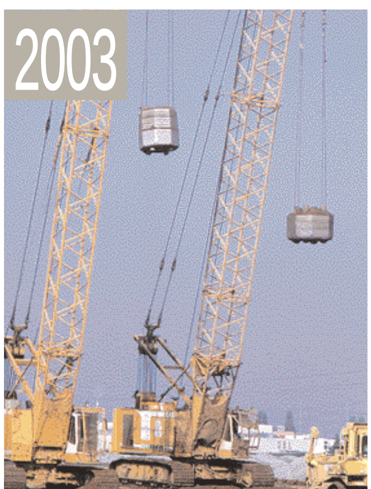
Nice airport (France).

Tripod, Gold Monument site (South Africa).

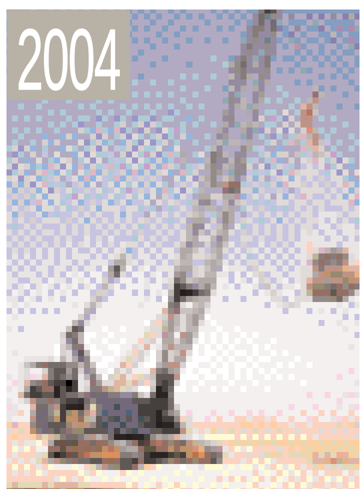
New generation of 700 t/m dynamic compaction cranes.

Birkenfeld site (Germany).

A89 road motorway, Brive (France).



Corbas Platform, Lyon (France).



Mars Process, Al Quo’a (Emirate of Abu Dhabi).

The Freyssinet Group around the world

Africa and middle-East

Egypt
Freyssinet Egypt
Giza
Phone: (20.2) 345 81 65
Fax: (20.2) 345 52 37

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

South Africa
Freyssinet Posten Pty Ltd
Olifantsfontein
Phone: (27.11) 316 21 74
Fax: (27.11) 316 29 18

Reinforced Earth Pty Ltd
Johannesburg
Phone : (27.11) 726 6180
Fax : (27.11) 726 5908

United Arab Emirates
Freyssinet Middle East LLC
Dubai
Phone: (971) 4 286 8007
Fax: (971) 4 286 8009

Freyssinet Gulf LLC
Dubai
Phone: (971) 4 286 8007
Fax: (971) 4 286 8009

America

Argentina
Freyssinet Tierra Armada SA
Buenos Aires
Phone: (54.11) 4372 7291
Fax: (54.11) 4372 5179

Brazil
Terra Armada Ltda
Rio de Janeiro
Phone: (55.21) 2233 7353
Fax: (55.21) 2263 4842

Canada
Reinforced Earth Company Ltd
Mississauga
Phone: (1.905) 564 0896
Fax: (1.905) 564 2609

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

Colombia
Stup de Colombia
Bogota
Phone: (57.1) 236 3786
Fax: (57.1) 610 3898

Tierra Armada Ltda
Bogota
Phone : (57.1) 236 3786
Fax : (57.1) 610 3898

El Salvador
Fessic SA de CV
La Libertad
Phone: (503) 278 8603
Fax: (503) 278 0445

Guatemala
Presforzados Técnicos SA
Guatemala City
Phone: (502) 2204 236
Fax: (502) 2500 150

Mexico
Freyssinet de México SA de CV
Mexico DF
Phone: (52.55) 5250 7000
Fax: (52.55) 5255 0165

Tierra Armada SA de CV
Mexico DF
Phone: (52.55) 5250 7000
Fax: (52.55) 5255 0165

United States
DGI - Menard
Bridgeville, PA
Phone: (1.412) 257 2750
Fax: (1.412) 257 8455

Freyssinet LLC
Chantilly, VA
Phone: (1.703) 378 2500
Fax: (1.703) 378 2700

The Reinforced Earth Company
Vienna, VA
Phone: (1.703) 821 1175
Fax: (1.703) 821 1815

Venezuela
Freyssinet Tierra Armada CA
Caracas DF
Phone: (58.212) 576 6685
Fax: (58.212) 577 7570

Asia

Hong Kong
Freyssinet Hong Kong Ltd
Kwung Tong - Kowloon
Phone: (852) 2794 0322
Fax: (852) 2338 3264

Reinforced Earth Pacific Ltd
Kwung Tong
Phone: (852) 2782 3163
Fax: (852) 2332 5521

Indonesia
PT Freyssinet Total Technology
Jakarta
Phone: (62.21) 830 0222
Fax: (62.21) 830 9841

Japan
FKK
Tokyo
Phone: (81.3) 5220 2181
Fax: (81.3) 5220 9726

TAKK
Tokyo
Phone: (81.44) 722 6361
Fax: (81.44) 722 3133

Malaysia
Freyssinet PSC (M) Sdn Bhd
Kuala Lumpur
Phone: (60.3) 7982 85 99
Fax: (60.3) 7981 55 30

Ménard Geosystems Sdn Bhd
Subang Jaya Selangor
Phone: (60.3) 5632 1581
Fax: (60.3) 5632 1582

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

Pakistan
Reinforced Earth Pvt Ltd
Islamabad
Phone: (92.51) 2273 501
Fax: (92.51) 2273 503

Singapore
PSC Freyssinet (S) Pte Ltd
Singapore
Phone: (65) 6899 0323
Fax: (65) 6899 0761

Reinforced Earth (SEA) Pte Ltd
Singapore
Phone: (65) 6316 6401
Fax: (65) 6316 6402

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

Sangjee Ménard Co. Ltd
Seoul
Phone: (82.2) 587 9286
Fax: (82.2) 587 9285

Thailand
Freyssinet Thailand Ltd
Bangkok
Phone: (66.2) 266 6088/90
Fax: (66.2) 266 6091

Vietnam
Freyssinet Vietnam
Hanoi
Phone: (84.4) 826 1416
Fax: (84.4) 826 1118

Europe

Belgium
Freyssinet Belgium NV
Vilvoorde
Phone: (32.2) 252 0740
Fax: (32.2) 252 2443

Terre Armee Belgium NV
Vilvoorde
Phone: (32.2) 252 0740
Fax: (32.2) 252 2443

Denmark
A/S Skandinavisk Spaendbeton
Vaerlose
Phone: (45.44) 35 08 11
Fax: (45.44) 35 08 10

France
Freyssinet France
Vélizy
Phone: (33.1) 46 01 84 84
Fax: (33.1) 46 01 85 85

Freyssinet International & Cie
Vélizy
Phone: (33.1) 46 01 84 84
Fax: (33.1) 46 01 85 85

Ménard Soltraitement
Nozay
Phone: (33.1) 69 01 37 38
Fax: (33.1) 69 01 75 05

PPC
Saint-Remy
Phone: (33.3) 85 42 15 15
Fax: (33.3) 85 42 15 14

Terre Armée SNC
Vélizy
Phone: (33.1) 46 01 84 84
Fax: (33.1) 46 01 85 85

Fyrom
Freyssinet Balkans
Skopje
Phone: (389.2) 3118 549
Fax: (389.2) 3118 549

Germany
Menard Dyniv GmbH
Seevetal
Phone: (49) 4105 66 480
Fax: (49) 4030 23 98 25

Bewehrte Erde
Seevetal
Phone: (49) 4105 66 48 16
Fax: (49) 4105 66 48 66

Great-Britain
Corrosion Control Services Ltd
Telford
Phone: (44.1952) 230 900
Fax: (44.1952) 230 960

Freyssinet Ltd
Telford
Phone: (44.1952) 201 901
Fax: (44.1952) 201 753

Reinforced Earth Company Ltd
Telford
Phone: (44.1952) 201 901
Fax: (44.1952) 201 753

Hungary
Pannon Freyssinet Kft
Budapest
Phone: (36.1) 209 1510
Fax: (36.1) 209 1510

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

Italy
Freyssinet Terra Armata SRL
Rome
Phone: (39.06) 418 771
Fax: (39.06) 418 77 201

Netherlands
Freyssinet Nederland BV
Waddinxveen
Phone: (31.18) 2630 888
Fax: (31.18) 2630 152

Terre Armée BV
Breda
Phone: (31.76) 531 9332
Fax: (31.76) 531 9943

Norway
A/S Skandinavisk Spennbetong
Snarøya
Phone/fax : (47.67) 53 91 74

Poland
Freyssinet Polska Sp z.o.o.
Milanówek
Phone: (48.22) 724 4355
Fax: (48.22) 724 6893

Portugal
Freyssinet - Terra Armada
Lisbon
Phone: (351.21) 716 1675
Fax: (351.21) 716 4051

Roumania
Freyrom SA
Bucharest
Phone: (40.21) 220 2828
Fax: (40.21) 220 4541

Russia
Freyssinet
Moscow
Phone: (7 095) 7475 179
Fax: (7 095) 7475 179

Spain
Freyssinet SA
Madrid
Phone: (34.91) 323 9500
Fax: (34.91) 323 9551

Tierra Armada SA
Madrid
Phone: (34.91) 323 9500
Fax: (34.91) 323 9551

Slovenia
Freyssinet Adria
Ajdovscina
Phone: (386) 5 36 90 331
Fax: (386) 5 36 90 200

Sweden
AB Skandinavisk Spaennbetong
Malmö
Phone/fax : (46.40) 98 14 00

Switzerland
Freyssinet SA
Moudon
Phone: (4121) 905 0905
Fax: (4121) 905 0909

Hebetec Engineering AG
Hindelbank
Phone: (41 34) 411 71 71
Fax: (41 34) 411 71 70

Turkey
Freysas
Kadiköy-Istanbul
Phone: (90.216) 349 8775
Fax: (90.216) 349 6375

Reinforced Earth Insaat Proje Ve Tic. A.S
Umraniye-Istanbul
Phone: (90.216) 484 4179
Fax: (90.216) 484 4174

Oceania

Australia
Austress Freyssinet Pty Ltd
Seven Hills
Phone: (61.2) 9674 4044
Fax: (61.2) 9674 5967

Austress Menard
Seven Hills
Phone: (61.2) 9674 4044
Fax: (61.2) 9674 5967

Austress Freyssinet VIC Pty Ltd
Melbourne
Phone: (61.3) 9326 58 85
Fax: (61.3) 9326 89 96

The Reinforced Earth Company
Hornsby
Phone: (61.2) 9910 9910
Fax: (61.2) 9910 9999

New Zealand
Freyssinet New Zealand Ltd Reinforced Earth Ltd
Auckland
Phone: (64.9) 2363 385
Fax: (64.9) 2363 385

FREYSSINET
1 bis, rue du Petit-Clamart - 78140 Vélizy-Villacoublay - Phone : 01 46 01 84 84 - Fax : 01 46 01 85 85 - www.freyssinet.com **Publication manager:** Claude Lascols - **Editor:** Stéphane Tourneur (communication@freyssinet.com)
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