Belgium

The Sart canal bridge
The use of high performance materials was included in the specifications imposed on contractors working on the Sart Canal Bridge. Why was this recommendation made?

We cannot talk about high performance materials without introducing the concept of quality rather than high performance concrete alone. The canal bridge is an innovation in its category since it is made of prestressed concrete, whereas in the past these structures were made of steel or reinforced concrete. The Ministry of Development wanted a steel structure, but we were able to convince them about the advantages of prestressing for the canal bridge due to our knowledge of this technique, its ease of construction and its advantages, and particularly the use of a sheathed and greased strands providing perfect protection. Prestressed concrete appeared to be an economic solution considering the specific nature of the project, the loads and relatively short spans.

More generally, the requirement for quality has existed since the dawn of time, but it was lost in Western Europe during the reconstruction after the Second World War. The criterion at the time was fast and inexpensive construction. Between 1945 and 1975 we forgot how to “build well” and we were carried away during the Golden Sixties and Seventies during which we lost our points of reference and lived beyond our means without thinking of future. The problems due to the oil crisis, the emergence of Japan where the quality concept was put into practice, and the realization that our buildings built twenty or thirty years earlier were not behaving well made us aware once again that quality should be a priority.

In the search for quality, should we talk about performance more than strength?

In the case of the Canal Bridge, high performance concrete is a high strength concrete, but this is not its most important characteristic. I think the expression “high performance” encompasses the concept of durability. We should work towards durability for concrete. As a result of research being done to achieve very high strength, we can envisage future uses of concrete similar to uses of steel structures. But we have not reached this point yet, so let’s just make good and attractive concrete. The quality of the materials and construction goes hand in hand with aesthetics. A high quality structure is the result of good architecture, good design and good execution.

We can no longer build without giving priority to the aesthetics of a structure and its integration into the environment. This principle is adopted as a starting point, and then we automatically move towards quality at all levels: stability, durability and a good selection of materials is essential.

Are quality criteria for a building the same as for a bridge?

The basic problem is the same in both cases. However, it may be different depending on the environment. In the case of the bridge over the Meuse, construction quality is the result of a special design including the search for an elegant structure integrated into its...
environment and the use of noble and de luxe materials. It is an urban structure. However the Canal Bridge is in a less attractive site and has overwhelming dimensions, consequently it is difficult to achieve a successful design and integration. The structure makes a mark across the landscape. We had a choice between two approaches: either a simple monotonous, understandable and restful structure, or a more animated structure making use of colors. We preferred the first option, and demanded a construction quality that enabled immediate acceptance of the structure so that the structure and its place in the environment could be immediately understood. The walls of the structure are modest with an architectonic pattern, the side walls are slightly curved and the transverse members visible under the deck make a clear statement about its structural function.

Quality also depends on work methods, both for the design and construction. Nowadays we benefit from high performance tools that we must use to the best possible extent to optimize the final performance of the construction, taking account of progress made in the construction of structures and new materials. The best example is prestressing derived from the stay cable technology, using thoroughly protected greased and sheathed tendons that can be replaced, thus offering better safety. The choice of incremental launching for the canal bridge has enabled us to build a structure with a better than average quality. We chose a method based on its many advantages rather than attempting to beat a world record by launching 65 000 tonnes.

What changes are being made in the fields of steel, concrete and new materials?

These materials should be considered separately because of their own different history. For concrete, we are closely monitoring developments in France such as Ultra-High Performance Fiber Reinforced Concrete (BFUP). This is a new material that will eventually need a new approach to design and special studies. We are moving towards concrete that would have homogenous properties. For "conventional" concrete that we use everyday, we need to work towards increased durability which is often jeopardized for economic or human reasons, since we suffer from a lack of qualified technical personnel.

For steel, significant progress has been made in terms of prestressing with an increase in the long term resistance. For structural steel, better known, the changes are less spectacular. At Greisch, we are very confident in the use of composite structures for bridges and buildings, combining the best qualities of concrete and steel. There is no limit to ways of combining the two materials. We have about 20 years experience with the behaviour of composite structures, and we are capable of undertaking daring designs. These solutions can only be produced by close cooperation between concrete specialists and steel specialists, although these specialists are too frequently still in competition with each other. It is also worth mentioning Ultra High Performance Synthetic Materials, the advent of which is awaited impatiently. Many problems remain to be solved in this field and their cost remains very high.

What are the relations between quality requirement and innovation?

The quality requirement and strict recommendations of the business oblige contractors to continuously rethink their policies and take risks. We used new techniques on the Wandre bridge, and we were fortunate in that we found contractors and suppliers willing to take risks and search for innovative solutions. This was how the waxed unbonded strand was first used, to satisfy a quality requirement about which everyone is now unanimous. Innovation is the corollary of the quality requirement.

Is there a satisfactory and ideal quality level?

Quality involves an ongoing search and continuous rethinking. Quality is not a matter of standards but rather a matter of organizing and improvement. Quality must never be stopped, there is a starting point but there should never be an end. The Quality search is unlimited.
France

Freyssinet receives an award from the FNTP

On January 25 this year, Daniel Tardy, president of FNTP (French National Public Works Federation) and Marcot Boiteux, president of the jury of the 10th Innovation award organized by the FNTP, handed over the second prize to Pierre Jaroux, Mike McClenahan and Ivica Zivanovic from Freyssinet for the "self-protected waterproof bridge suspension system" presented in cooperation with Atofina and Tréfileurope. The individually protected stay cable provided the inspiration for COHESTRAND™ which is composed of a single 15.7 mm diameter strand provided with a multi-barrier protection consisting of (in order from the inside towards the outside) galvanization, hydrophobic bonding product covering all wires in the strand bonded to the steel, and a 1.5 mm thick layer of HDPE. COHESTRAND™ is fully compatible with the Freyssinet anchor system and is applicable to large suspension bridges or more modest structures, new construction and bridge repair. Chartreuse bridge is the first application of COHESTRAND™ (Freyssinet magazine N° 207, March 2000).

Mexico

Chiapas bridge

Freyssinet de México is participating on behalf of the ICA company on the construction of a bridge in the State of Chiapas in the South of Mexico. The bridge passes over an artificial lake and carries the road joining the states of Veracruz and Chiapas. Therefore, the project is very important for Mexico. Its length is 1208 m and its width is 10 m wide, and it comprises eight spans (92 - 152 - 5x168 - 124 m). Initially, the bridge will carry two traffic lanes with a planned extension to four. The deck is composed of steel box girders with an orthotropic slab, and is built by incremental launching. It comprises a 50 m long nose and a cable stayed mast with four pairs of 25T cables. The deck is supported by offshore type steel piers formed by four 2.77 diameter main pipes. Freyssinet is responsible for construction methods, incremental launching operations, the supply and installation of TETRON™ type bearings and expansion joints.

Brazil

A new building for the Rio Stock Exchange

Freyssinet Brazil is participating in the construction of the new head office of the Rio de Janeiro Stock Exchange subcontracted from Wobrel Construtora SA company, and is supplying and installing post-tensioning cables for the floor slabs on 12 storeys. The slabs are 0.16 m thick and consist of 30 m long 7.5 m wide panels. The total area is 6 000 m². The floor prestressing uses the Freyssinet C system (4F13) and uses 120 t of steel.

France

Mont-Blanc tunnel

Freyssinet is working on part 5F within a group composed of Bouygues, GTM-Dumez, Impregilo and Freyssinet, for ATMB, the client, and the Scafa route Spea group, the engineer. The work that will employ 50 persons at Freyssinet, is to repair and drain the tunnel roof and the ventilation ducts (100 m² makeup on the roof and 23 000 m² waterproofing of the slab), profiling the tunnel roof, coring and drilling of communication openings between ventilation ducts, and finally drainage and road surfacing work (800 m for the renovation of active duct joints). Freyssinet teams will be working six days out of seven, day and night.
In brief

Turkey

Construction of a supermarket in Bursa

After the Izmir compaction project in Turkey, Carrefour has once again asked Menard Soltraitement to improve soils at the future Bursa Carrefour shopping centre. The project will include a supermarket, a shopping centre and a two storey car park with a total floor area of 103,000 m². The objective on this site was to make the large variety of soil materials (natural terrain, waste, demolition materials, recent 12 m thick backfill) homogenous and to guarantee an absolute settlement of less than 15 mm. The stone columns technique was used under the footings, and the conventional dynamic compaction technique was used under slabs on grade. Areas with thick overburden were treated using high energy compaction machines. Furthermore, two cranes were rented locally for the low energy compaction phases and for the treatment of fairly shallow areas. The construction work was completed in three months. Particularly detailed geotechnical monitoring (790 pressure meter tests, five compaction columns and 40 seismic tests) were carried out to verify that criteria imposed by the resident engineer (ZETAS) for this work was satisfied.

United Kingdom

A new access ramp construction method

As part of the continued expansion and improvements to the Terminal, a new vehicle and passenger building was required to allow high vehicles access onto a new range of ferries. Space restrictions limited the ramp to a tight curvature from dock level, leading to a bridge spanning the new customs area onto the new building roof at ferry access level. The ground conditions across the site were poor, with highly compressible alluvial material to considerable depth. Kier Northern were the successful contractor, and a combined solution of reinforced earth and band drains was developed between Kiers, Reinforced Earth Company and Len Threadgold of The Geotechnical Centre. In addition, a new facing panel system "TerraQuad" was developed to achieve the required 18 m radius of the internal ramp walls. The ramp was partially constructed on the completed band drains during Autumn 2000, with temporary overload placed at the bridge abutment position. Over the winter and Christmas break the ramp was allowed to settle, with the rate and degree of settlement being monitored against the conjectured figures from calculation. During early 2001 the settlement of approximately 500 mm was sufficiently complete to allow the completion of the last layers of Reinforced Earth up to finished level, and the construction of the road base and parapets. The bridge abutment was constructed and the bridge beams placed as the main building construction continued.

United States

San Luis Rey Water Treatment Plant

Menard Soltraitement has recently started up in the United States and is working on the extension to the San Luis Rey Water Treatment Plant in Oceanside, California. The work is being done using vibro replacement (stone columns).

TFC® selected by the HITEC

The HITEC (High Innovative Technology Evaluation Center) was created with the objective of collecting and disseminating information about the performance of new products. Freyssinet is using its experience with the Carbon Fiber Fabrics (TFC®) process for the strengthening of structures, and is actively participating in the program for the evaluation of fiber reinforced polymer composites (FRP) used for the consolidation and repair of concrete, and carried out by the HITEC. This program is supported by the AASHTO (American Association of State Highway and Transportation Officials) and the Federal Highway Administration (FHWA). The HITEC works as an independent organization under the control of the CERF (Civil Engineering Research Foundation), within the ASCE. The program is planned to start this year and includes laboratory and in situ tests.

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Main characteristics

- Bridge length: 498 m.
- Width between bearings: 33.4 m.
- Width at top: 46 m.
- Weight of bridge: 65 000 t.
- Number of spans: 13.
- Number of columns supporting the deck: 28.
- Water weight: 80 000 t.
- Final weight per column: 6 000 t.
Prestressing

The Sart Canal Bridge

The exceptional dimensions of the Sart Canal Bridge are necessary for modernization of the Centre canal. Freyssinet is supplying and installing prestressing for the new bridge.
The Sart Canal Bridge is located close to the town of La Louvière in Belgium, 50 km south of Brussels, and its construction is necessary for modernization of the Center Canal, now restricted to 300 tonnes convoys and classified as World Heritage by Unesco. It connects the Scheldt dock to the Meuse dock, and will carry 1,350 t barges over a valley eroded by the Thiriau river and a crossroads of the RN 55 and RN 535 roads close to a motorway interchange.

The dimensions of the structure under construction are exceptional and it has an innovative design that required unusual architectural, town planning and landscaping studies so that it would blend perfectly into its environment. The 498 m long deck comprises thirteen 36 m continuous spans and two 15 m cantilever end spans. It is supported on twenty-eight 3 m diameter circular columns with 10 m square foundations supported on nine 1.5 m diameter piles 10 to 20 m long. The bottom of the deck is stiffened by 111 27 m long fish bellied diaphragms at c/c distances of 4.5 m. The average thickness of the bottom slab is 40 cm and it is as thick as 60 cm at the piers. The width between bearings is 33.4 m and the width at the top is 46 m. The Sart Canal viaduct supports 80,000 t of water, eight times more than the weight carried by a road bridge. Pedestrians can walk along the 6 m wide service roads on each side of the canal. The simplicity of forms combined with the use of high performance materials and discrete facilities contribute towards the genuine character of the Canal Bridge.

“A longitudinal and transverse prestressing cable system makes the bridge perfectly watertight”

However, this relaxing architecture conceals a project with a tricky design and advanced engineering, which mobilized a large number of engineers, architects and landscape artists. The structure needed to be designed to withstand the presence of water at all times which is why it is composed of high strength materials, and the settlement of the support piles needed to be compatible with the magnitude of the loads from the structure, with each column supporting final loads of 6,000 t.

Methods that respect the environment
The canal bottom is placed by incremental launching of 12 m segments. The prefabrication area is located behind the west abutment and is like a genuine factory in which many operations are automated, resulting in time savings necessary for execution and the construction of 12 m segments every week. This organization guarantees that the structure is uniform and concrete is placed under optimum conditions. With this method, it is possible to do the work with no interruption to traffic or effect on the environment. This “plant” comprises storage area for prefabricated diaphragms and shuttering slabs, prestressing ducts and a formwork area for integral prefabrication of reinforcing cages. The deck is equipped with a 21 m nose composed of steel webs and prestressed concrete.
top and bottom flanges, and is launched by a system composed of four jacks with a stroke of 2 m and an individual capacity of 500 tonnes. Neoprene-Teflon sliding bearings and guide devices fixed on the top of columns. The 65 000 tonne final bridge weight is a world record for incremental launching.

A waterproof bridge

Due to its special purpose, the canal bridge has to satisfy a number of requirements such as thick and waterproof walls. Designers achieved this by using reinforced concrete combined with prestressed concrete. A longitudinal and transverse prestressing cables system was designed to produce two-directional compression in the concrete in all parts of the structure in contact with water and thus provide perfect waterproofing, and the system was installed by Freyssinet Belgium. Another specific feature is that the canal viaduct is supported on a limited number of bearings to take account of the various aesthetic
and technical criteria. This feature makes the structure very transparent. The continuity of the longitudinal load bearing element combined with rigid side walls gives good resistance to earthquake. A number of measures are taken to make the bridge waterproof, such as minimizing the number of expansion joints, the use of dense concrete, the use of three-dimensional prestressing and placement by hot gluing of a waterproofing membrane protected by a coat of poured asphalt.

The 7.1 m high side walls on each side of the deck are inclined and protect the external walls of the structure against precipitation. The 90 cm thick side walls are longitudinally prestressed in the center by six 27C15 tendons that compensate for the lack of tensile strength of the concrete during launching operations. Three 27C15 continuity tendons, tightened after launching and before the canal viaduct is filled with water, are additional to the device. The diaphragms are prestressed in the factory by two 19C15 tendons and two 27C15 tendons installed during construction of the deck. The longitudinal prestressing of the bottom of the canal placed and tightened during the launching operations is composed of fifteen 12C15 tendons. The entire prestressing is applied using Freyssinet T15 unbonded strands threaded into an HDPE duct grouted with cement grout. This prestressing provides an excellent protection against corrosion, and can be adjusted and replaced strand by strand.

Participants

Client: SOFICO (Société Wallonne de Financement complémentaire des Infrastructures - Wallon Complementary Infrastructure Financing Company).
Engineer: M3T221 (Mons Waterways Division).
Design office: Greisch (GEG Group).
Inspection office: SECO.
Main contractor: BAGECI short term Association - CFE - FRANKI CONSTRUCT
Specialized contractor: Freyssinet Belgium.

The entire prestressing is applied using Freyssinet unbonded strands threaded into an HDPE duct filled with cement grout.
The total project occupies an area of 400,000 m², with 250,000 m² of construction, including the shopping centre itself that comprises 60,000 m² of basement car parks, a ground floor occupying 60,000 m² and is designed to contain shops and recreation areas, also a first floor occupying 40,000 m² divided into four independent buildings for use by shopping and leisure areas (cinema, bowling, etc.).

The ground floor and the first floor consist of post-tensioned concrete slabs 25 to 40 cm thick. The use of prestressing has made it possible to reduce the thickness of the slabs, increase the spans and to obtain 270 x 240 floors with no expansion joints on the ground floor. This solution also made it possible to reduce construction times. The rate of construction for a square panel 32 x 32 m was very quickly reduced to four days including formwork, reinforcement fixing and concreting, and tensioning of the strands. A total area of 100,000 m² of slabs were constructed and post-tensioned, at an average rate of 3,600 m² per week. At this sustained rate, construction of all slabs was completed in just seven months. This site is a remarkable landmark in the use of post-tensioning in building, since formerly post-tensioning had only been used in Spain for bridge construction.

Thinner slabs and even longer spans

The 25 cm thick ground floor slabs are cast in situ and post-tensioned. There are no expansion joints. They are constructed in 32 m square panels. The active reinforcement is bonded and composed of flat ducts containing four strands each. The conventional reinforcement consists of about 1,760 tonnes of steel for the 60,000 m² constructed. The 2,757 prestressing anchors are of the Freyssinet type 4C15. 7,184 T15 single strand couplers were used to achieve continuity of prestressing from one panel to the next. There is a total of almost 322 tonnes of conventional reinforcing steel.

The adopted solution on the first floor on which four independent buildings were constructed is identical to the solution on the ground floor. However, the total area to be constructed is smaller, namely 40,000 m², whereas the 16 x 16 m spans are larger. 3,347 active anchorages, 501 passive anchors and 3,456 couplers were used for these floors, with a total of 355 tonnes of active reinforcing and 1,760 tonnes of conventional reinforcing.

Participants

Client: Riofisa SA Group.
Engineer: Idom Internacional.
Structure engineer and project designer: Engineer Guillermo Corres Peretti.
Main Contractor: Necso Entrecanales y Cubiertas SA.
Inspection office: INTEMAC SA.
Specialized contractor: Freyssinet SA.
A suspension bridge was built between Saint-Gilles and Arles in the Gard department, shortly after the Second World War, to carry national road 572 over the Petit Rhône. This bridge was closed to traffic in 1984 after serious deficiencies were observed on the suspension cables, and in 1985 it was replaced by a temporary army bridge on the downstream side composed of two Bailey bridges. The deck of the bridges is composed of 3.05 m long panels forming the two main girders. The panels are assembled by pins. The bridge is 3.81 m wide and has wood surfacing (replaced in 1993), and consists of two 39.62 m spans and two 42.67 m spans supported on three piers in the Rhône, giving a total length of about 165 m. The upstream bridge also includes a pedestrian footbridge.

In 1995, an inspection showed that deflections in girders were excessive. It was then decided to reduce the allowable tonnage on the bridge from 38 to 19 t and to install heavy strengthening. A new cable stayed bridge was opened to traffic at the end of 1999, and the temporary bridge considered to be dangerous in rainy weather, noisy due to its wood surfacing and with insufficient clearance for navigation, was permanently closed to traffic after fifteen years of service.

Disassembling the Bailey bridge

All pins and attachments were treated using a thread release agent before the work was started. The work started with the disassembly of the top bracing and the third level of side lattice, consisting of two times three transverse panels for each bridge. The operation was done using a crane located on the existing structure and the elements were loaded onto a special purpose trailer.

The second work phase was to restore the longitudinal level of the bridge by lifting the various spans. The existing bearings would then be removed. The structure was then placed on temporary rollers and the four simple spans were fastened together. This work was done span by span. Span No. 2 was lifted by 0.35 cm and span No. 1 by 1.5 m on the abutment and 0.35 m on pier 1. Span No. 1 was pulled towards span No. 2 and broached. Permanent rollers were installed on pier No. 1 and on the abutment. The 25 m long rear nose was fixed to the structure on the abutment. It consisted of standard bridge panels. The operation continued by lifting span No. 4 by 3 m on the abutment. A 8 m long preinstalled front nose was then fixed, which placed the bridge on wood packing on the backfill. This system avoided the need for 3 m of packing on the abutment. The next step was to lift span No. 3 by 1.5 m on pier No. 3 and 0.35 m on pier No. 2, to install temporary rollers. Span No. 3 and span No. 2 were broached and placed on final rollers located on pier No. 3 and on the abutment.

With the bridge thus prepared, the third phase (launching) could be started. Two SC2 jacks were fixed onto a metal frame clamped to the abutment by means of prestressing rods. The strand was attached by a metal shoe located under the side beams of the deck. The wood planks were disassembled as the work progressed to make sure that personnel were safe at all times until the work on the piers was complete.
When the new stayed cable bridge was constructed in 1999, it was decided to deconstruct the temporary Bailey bridge that was considered to be dangerous.

Under this configuration, the bridge was launched in segments of about 20 m and gradually disassembled by means of a self-powered crane on the incremental delaunching area. Removed elements were loaded onto a special purpose trailer and transported to the CNPS (Centre National du Pont de Secours - National Prefabricated Bridges Centre) in the Paris region.

**Participants**

- **Client:** Gard General Council.
- **Engineer:** Gard Development Authority.
- **Main contractor:** Freyssinet France.

**Delaunching principle**
A new service station has been built on the E19 motorway between Paris and Brussels close to the town of Nivelles on the Orival layby, and is protected by an overpass. Samyn was the architect for the overpass-restaurant currently under construction. The overpass is an innovative structure composed of two master girders connected by 25 m lattice cross members supporting the floor of the overpass-restaurant at the bottom and the roof at the top. The restaurant, installed at the center of the four structure and roof bearings, and supported by 70 m brackets, extends as far as and above both service stations.

A vibration problem

The structure is slender. Movements of the brackets induce significant vertical movements at the mid-span due to the ratio of the length between the cantilevers and the central span. These 70 m long very flexible cantilevers can vibrate under the effect of wind and induce vertical accelerations at mid-span at the restaurant that can disturb users. Therefore, the TotalFinaElf company appointed Freyssinet to find a damping solution for this structure to lower movements and accelerations to values that would guarantee the comfort of their future customers.

A maximum vertical acceleration of 0.1 m/sec/sec was selected as a comfort criterion. The Technical Department of Freyssinet International proposed the use of four TRANSPEC SHA® hydraulic shock absorbers at each end of the brackets, to reduce the vibration phenomenon.

Hydraulic shock absorbers

Based on a model of wind effects carried out by the SETESCO design office, Sigmatec Engineering analyzed the dynamic behaviour of the footbridge using a modal analysis of the undamped structure and a time history calculation by direct integration of the response of the damped structure subject to dynamic pressures induced by wind, modeled by harmonic frequency functions, the natural frequencies of the undamped structure. The undamped structure is subject to resonant frequencies, the most significant of which vary firstly between 1.03 and 1.04 Hz causing torsion about the longitudinal axis of the brackets in phase and in phase opposition, and secondly between 1.16 and 1.25 Hz causing vertical vibration of the brackets in phase and in phase opposition. The sensitivity study defined the damping performances and stiffness characteristics required, and was used to select the shock absorbers: TRANSPEC SHA® 110 – 450 units were used with a nominal capacity of 110 kN. The shock absorbers developed by the Technical Department of Freyssinet International and made by the PPC company were installed at the ends of each span. They connect the structure to the ground through a cable stayed mast. The length of the TRANSPEC SHA® is 1570 mm including the attachment clevis, and the outside diameter is 225 mm. It is hinged at its base to a concrete foundation and is embedded at the top at its connection with the cable stayed mast. The stroke of the TRANSPEC SHA® is 450 mm, and they are installed pre-adjusted such that the distance is 200 mm when closed (when the structure moves down) and 250 mm when open. This hydraulic shock absorbing device was determined using a nonlinear damping law F = Cv^n. The hydraulic regulation device is adjustable and validated by in-situ tests.

Participants

Client: TotalFinaElf
Main contractor: Architect Samyn, SAI Company
Design Office: SETESCO
Structural dynamic analysis: Sigmatec
Specialized contractor: Freyssinet Belgium
The adopted solution uses TechSpan® arches, due to their engineering advantages and the flexibility of construction using this process. The structure, 4.5 m span and 5 m high, is composed of precast concrete elements according to the recommendations made by the consulting engineer Connell Wagner, forming keyed half shells. The 2.5 m wide arches are manufactured by PCP Pty Ltd in Kilkenny.

The TechSpan® process proposed by Reinforced Earth Company offers technical and financial advantages. Technically, the structure must firstly support the loads and forces from waves, and secondly it must respect severe durability requirements imposed on structures in the saltwater environment. Thus, 200 m of tunnel is being placed inside a coffer dam and will be permanently submerged on the sea floor. Engineers at the Reinforced Earth Company chose TechSpan® arches based on the funicular curve theory, and made the best use of the properties of concrete by creating a 150 mm thick arch that can bear a 12.5 m of sand and the weight of future 40-tonne trucks carrying sand in the region. Apart from the arches, Reinforced Earth Company also participated in the design and supply of precast base slabs for the raft, adapted to the geological variations of the seabed, in this case composed mainly of clay and sand. Each slab was designed taking account of the type of seabed.

The Baulderstone Hornibrook company is building a flushing tunnel for the evacuation of water from the Patawallonga lagoon to the ocean in the Glenelg district in Adelaide.

"The structure must withstand loads and forces due to waves, while respecting durability requirements imposed on structures in a salty environment."
Better integration into the environment

Reinforced Earth is in contact with nature at all times and is continuously developing technologies and products designed for conservation and protection of the environment.

The initial characteristics of Reinforced Earth products such as their placement (for which no concrete pouring, geographic modification of sites or heavy machines are necessary), their faster construction and their small influence on the backfill, combined with architectonic forms, textures and the variety of colors of concrete surfaces, enable a harmonious integration of the structures into urban and rural sites. Each project is a special case that needs different engineering and plastic solutions, as illustrated by the following four structures.

Noise absorption walls for sound protection

In terms of protection of the environment, Tierra Armada SA has just completed construction of a noise absorption screen wall designed to protect a residential area from noise at Barajas Madrid airport (Spain). It is a conventional 2,650 m² wall with buttresses, 9 m high, with a porous concrete sound absorbing screen on the facing.

The noise absorption screen wall is made based on mortar with wood and cement fibers. The grooved finish of the surfaces provides a variety of different decorations and colorings, in harmony with the environment. Its main advantages are its high sound insulation, mechanical strength, durability, easy maintenance, and that it can be adapted to all types of ground.

Due to the unusual height of the noise absorption screens, erection was done using double H steel profiles anchored into cast in situ foundations.

Participants

Client: SACYR SA.
Main contractor: AENA.
Design Office: Setesco.
Specialized contractor: Tierra Armada SA.

Reinforced Earth Contractor producing works of art

There has been a growing trend in Texas for owners of proposed retaining walls to specify unusual facing panels which make an architectural statement for their project. No owner has been more active in this regard than the Texas Department of Transportation (TxDOT), where Mr. Mark Bloshock, Engineer for Special Projects in the Bridge Division, has provided both coordination and inspiration. He has served as the coordinator between TxDOT’s various geographical Districts and
Mr. Bloschock cites that various Districts that are planning projects. His inspiration comes in the form of encouragement to the methods of construction. His inspiration modeling of structures, and the evaluation of efforts have involved various feasibility studies, Reinforced Earth Company (RECo). His the retaining wall industry, including The Reinforced Earth Company (RECo). His efforts have involved various feasibility studies, modelling of structures, and the evaluation of methods of construction. His inspiration comes in the form of encouragement to the various Districts that are planning projects. Mr. Bloschock cites that “It is a very competitive thing among our District Engineers and therefore our Districts are trying something different, pushing the edge, taking a risk, ... that sort of thing.” He added, “The smaller Districts feel they need to get out there and put themselves on the map. The artistic thing is something we developed internally. The wagon was developed by them (the Childress District). They initially had a lot of very complex art. We kept the level of detail down, but kept folks really interested in something that was unusual.” RECo has been instrumental in this process by offering specialized designs performed by its engineering staff in Euless, Texas and by supplying high-quality precast panels from its manufacturing plant in Waco, Texas. The artwork is typically formed by using full-size blockouts made from templates that are prepared with precision by RECo’s engineers. These templates are used at RECo’s manufacturing plant to fabricate the blockouts, which in turn are carefully set at exact locations within the forms. Finally, close control by the project manager brings the pieces together. The results are remarkable, as Mr. Bloschock states, “I think everybody who looks at this doesn’t really see the joints and doesn’t see any translation between the joints – they are seeing the art. RECo ought to be pretty proud of that.

An ogival arch was poured in situ near the bottom of the reinforced earth wall, to form a passage to be followed by the stream at the bottom of the valley.

**Full height walls adapted to curved structures**

The experience of creating wagons, windmills, wheat fields, birds, medallions, viaducts, etc. has given RECo the confidence that it can continue to play a major role in meeting the special architectural needs of its clients in Texas, and beyond.

**A slope stabilized by terraced walls**

The embankment needed to be stabilized as part of the work to widen the RD908 road in the Hérault department in France; this was done by two Reinforced Earth structures to cross over two valleys in the commune of Colombière-le-Poujol. This solution reduced the surface area occupied by backfill. The largest structure with an area of 2,100 m² and a height of more than 28 m, is the result of an architectural study carried out by the architect, André Mascarelli so that it would blend well into the environment. The adopted solution makes use of TerraClass surfaces laid out in four terraces. The surfacing consists of washed gravel from the Vergèze quarry with an architectonic finish composed of horizontal grooves on the facing to suggest dry stone.

The results are remarkable; as Mr. Bloschock project manager brings the pieces together. Finally, close control by the project manager brings the pieces together.

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**Participants**

**Client:** Hérault General Council  
**Engineer:** Hérault Development Authority  
**Architect:** André Mascarelli  
**Main contractor:** BEC  
**Specialized contractor:** TerreArmée
Soil consolidation

The new Alexandria shopping centre

Menard Soltraitement was appointed to perform soil improvement work and earthworks on Lake Mariout, where a shopping centre will be built.

The greater Alexandria area already extends for more than 20 kilometers along a narrow coastal strip along the Mediterranean, and its population is increasing sharply in the same way as everywhere else in Egypt. The only way to build any more large infrastructures is to spread inland towards the 60-kilometer long Lake Mariout. Land reclaimed on this semi-marshy salt water lake has been affected by large settlements, as demonstrated by the many buildings in which the first floor balconies are now at road level. During the year 2000, Menard Soltraitement successfully bid for a contract for the design and execution of soil improvement work and earthworks in order to build a 220 000 m² shopping centre on reclaimed land on Lake Mariout, close to the international airport and the motorway between Alexandria and Cairo. This shopping centre will eventually be operated by the Carrefour company which has decided to make major investments to expand in Egypt.

Pre-consolidation

The nature of the ground, composed of 7 to 8 m thick layers of soft clay and silt and then loose sand, makes special treatment essential to guarantee the durability of the construction. The technical solution presented by Menard Soltraitement as a variant to the basic solution consisting of a floor supported on piles, which is very expensive for an area this large, is based on preconsolidation of the clay layer using vertical drains together with preloading, and the use of driven stone-filled pillars. The solution proposed by Menard Soltraitement is now well advanced for the definition of the shopping centre project, and takes account of the desire expressed by the customer to be able to move the location of the buildings anywhere within the covered area, for architectural reasons. Therefore, the grid used for drains, pillars and preloading heights were calculated by Signatec Engineering (Menard Soltraitement’s digital calculation and simulation subsidiary) to achieve a differential and long-term settlement for a uniformly distributed load of 2T/m² and point loads of up to 70T at unknown locations. The grid of drains and
preload heights were adapted to the durations determined in planning.

Heavy construction means

The soil improvement and backfill on an area of 220 000 m³ necessitated the placement of 1 250 000 m³ of materials, the installation of 1 500 000 m of vertical drains (more than six times the distance from Alexandria to Cairo) and the construction of 6 500 driven stone filled pillars. The work was split into four phases for which deliveries are staggered from September 2001 to July 2002. The first segment of the work currently in progress consists of 72 000 m³ and 45% of the work, but it must be completed in only 30% of the total time assigned to the soil improvement and earthworks. This is the area in which the first buildings in the shopping centre will be built in September 2001, while soil improvement and earthworks continue on areas set aside for the future extension of buildings and car parks. It is planned that the shopping centre will be opened in September 2002.

The work actually started in the month of September 2000 with the construction of a 1070 m dike around the site and across lake Mariout, followed by pumping of 300 000 m³ of trapped water. Specialized equipment belonging to Ménard Soltraitement was shipped from Europe during this period. Backfill in the first area with a draining work platform composed of sand was terminated in January 2001, following this the installation of vertical drains (1500 units per day), the construction of driven stone filled pillars (40 units per day) and work on applying the preload was commenced. At the present time, this preload is being applied at a rate of 10 000 m³ per day and the same cycle will continue in the second phase of the works. More than a hundred persons are working on this project. The geotechnical monitoring of the site is done using 120 measurement instruments installed at depths of up to 15 m.

ALEXANDRIA SHOPPING CENTRE
PROJECT SUMMARY

<table>
<thead>
<tr>
<th>Building areas</th>
<th>Car park areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load conditions</td>
<td>70T footings, Uniformly distributed load 2T/m²</td>
</tr>
<tr>
<td>Grid of vertical drains</td>
<td>From 1.10 m to 1.25 m</td>
</tr>
<tr>
<td>Grid of driven Stone filled columns</td>
<td>5.5 m</td>
</tr>
<tr>
<td>Preconsolidation time</td>
<td>5 to 7 months</td>
</tr>
<tr>
<td>Height of preloads</td>
<td>5.7 m to 6.2 m</td>
</tr>
</tbody>
</table>

Participants

Client: MAF MISR. Main contractor: CIA International (Orléans). Specialized contractor: Freyssinet Egypt under license from Ménard Soltraitement (Soil improvement and earthworks).
The enormous spider web shaped glass roof built by Austress Freyssinet to join the two towers in Aurora square is the distinctive symbol of this urban complex.

The canopy is multi-purpose - to act as a windbreak for the downward force of the wind between the two new towers, an architectural link for the two projects and a signature piece of urban architecture. Austress Freyssinet was contracted to design and build the glass canopy in keeping with the overall architectural concept, conceived by Italian architect Renzo Piano. Delivering the architectural vision whilst keeping to the client's budget was a challenging aspect of the project.

Located between Phillip and Macquarie Streets in Sydney is the twin tower development of Aurora Place. Adjacent to Macquarie Street is the 20-storey Residential Tower with the 45-storey commercial Tower on Phillip Street. The concept for the glazed canopy as envisaged by Renzo Piano, was for the canopy of glass supported by a “spider’s web”. The canopy would provide protection from the elements in the Piazza area whilst allowing maximum transparency through the glass and its structural elements. The canopy has a plan area of approximately 650 m$^2$ and is suspended between the 25 storey residential building and the 45-storey office building in Macquarie Street, giving a maximum span of about 30 m. A cable net provides support for the frameless glass, formed into an anticlastic surface to ensure structural resistance to both downwards and upwards loading.

The canopy is a particularly complex structure to design, each component connection and glass panel required individual design and detail drawings. The glass surface is suspended from the cable net via hangers located at each of the 300 intersection points of the cable net. Another unique feature is that the glass is wrapped into a shape that will provide positive falls to a single drainage point at the northern edge of the canopy. The concept of the typical cable net, as proposed and developed by Austress Freyssinet is the 18mm diameter, high tensile, stainless steel rods connected at each intersection via stainless steel cat nodes. The glass is typically 18mm thick fully toughened heat soaked laminated and patch supported at each corner via stainless steel cast spiders. The link between the glass plane and the cable net is via varying diameter (and length) stainless steel circular hollow sections 22mm to 70mm diameter. The north and south edges of the cable net are supported via edge cables of 44mm diameter from which these cables provide the means to tension the net prior to placing the glass.

**Participants**

Architect: Renzo Piano.
Project leader: Bovis Lend Lease.
Design: Lend Lease Design Group/Ove Arup.
Specialized contractor: Austress Freyssinet.
Freyssinet Thailand Ltd has been working on phase EW-1 of Wat Nakorn-In bridge between Bangkok and Thonburi, since the beginning of the year 2000.

The Sumitomo Construction and Italian Thai Development joint-venture is the main contractor for this project. It comprises firstly the construction of a cast-in-situ balanced cantilever box girder bridge over the Chao Praya river (built using a travelling formwork) and the access viaducts on the Thonburi side using the span by span cast-in-situ box girder method. It also includes the construction of the access viaducts on the Bangkok side erected with an overhead truss using the span by span method for the segmental box girder and three main bridges crossing over the Bangkruai Sanoi road on Thonburi side, and the Piratbonsongkrith road and the Pracharat road on the Bangkok side, constructed by the precast segmental method. The work done by Freyssinet Thailand applies to technical assistance for construction methods and prestressing work, the supply and installation of more than 700 tonnes of tendons and 1,356 Freyssinet 19C15 type C anchorages in 78 of the box girder viaducts. Each span comprises six 40 m long 19C15 cables and two 80 m long continuous 19C15 cables. Freyssinet is also responsible for the conceptual and detailed design of the existing overhead erection gantry to adapt it to the project, including the production of the construction sequences. The project started in April 2000 and will be completed in July 2001. It will be opened to traffic in the Bangkok North region at the beginning of the year 2002.

The Oaks Bridge overpass carries the C2104 road between Strensham and Twyning over the M50 motorway between junction 8 on the M5 and junction 1 on the M50 in the Worcestershire. Freyssinet UK was appointed to carry out the complete refurbishment of the bridge deck (including concrete repair, re-waterproofing, replacement joints, new kerbing, resurfacing, and new safety fencing on the approaches), the work to break out the existing concrete handrail and recast to a new profile, replacement of the steel parapets with aluminium parapet. The four wing walls were recast and tied together below carriageway with high strength bars. Freyssinet chose a cantilevered gantry system as a working platform to carry out hydrodemolition of the existing concrete handrails and also as a falsework support to formwork for the replacement concrete. The gantry system was partially prefabricated off-site, then erected (and dismantled) during overnight closures of the M50. The gantry was fully enclosed, allowing 24 hour working to proceed for both hydrodemolition and replacement works over the live motorway without the need for lane closures. In all 40 m³ of concrete was removed by hydrodemolition.

Participants

Client: Highways Agency.
Engineer: W.S.P. Group Plc.
Main contractor: Freyssinet Ltd.
The glass roof between the Philip Street and Macquarie Street twin towers was designed by the architect Renzo Piano and built by Freyssinet.

Photograph: Adrian Hall