

Freyssinet

SEPTEMBER/DECEMBER 2001 - No. 212

M A G A Z I N E

Romania

The Cernavoda bridge



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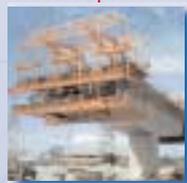
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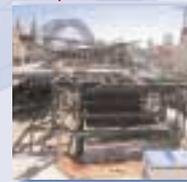
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Viewpoint

Environment: What is the answer?

Today, environment as a concept is inextricably linked with the construction and civil engineering trades. For this reason, the *fib* (fédération internationale du béton) decided to focus on the subject "concrete and environment" on the occasion of the Berlin symposium held on 2-5 October 2001. Questions asked to Hans-Ulrich Litzner, general representative of deutscher Beton- und Bautechnik-Verein E.V. and event organizer.



Hans-Ulrich Litzner, general delegate of the Deutscher Beton- und Bautechnik-Verein E.V. association created in 1898 and organizer of the *fib* said "We chose environment as main topic because it is current state and it concerns construction contractors".

Sustainability: is development that meets the needs of the present without compromising the ability of future generations to meet their own needs

FM: Is environment a passing phenomenon or have we always been concerned about it?

H.-U. L: In Germany, the environment is an extremely serious and very political subject. People might see it as a passing phenomenon, but in fact there is nothing new about it. Looking back in the past, we can see that there has always been close interaction between construction and the environment. In 1757, a German forester named Carl Von Carlowitz suggested to organize management of forests from which the wood was used for construction, and he argued for a better equilibrium in the use of materials. At the Rio de Janeiro Conference in 1992, the SIA (Swiss Society of Engineers and Architects) bulletin reported an increase in the number of articles dealing with environment and its consequences on the construction industry. Commission 3 at the *fib* conference in Berlin, responsible for environment and materials, considered three major themes, namely protection of man against environment, harmony between structures and environment, and the choice for the use of materials. We chose the environment topic because a lot of interest is paid to it at the moment and it concerns construction contractors. People are particularly interested in environment now for two reasons - industrialisation of countries and politics. Politics always plays a very important role that is often difficult to reconcile with the interests of construction contractors. Thus the earliest laws on environment were developed in Germany and Japan, and have now spread throughout the world.

What does this concept include?

Three elements have to be considered when talking about environment, namely economy, ecology (the balance between nature and structure, particularly in terms of energy consumption) and social. The social aspect is undoubtedly the most important but is also the most difficult to define. The environment guide published by German authorities illustrates this difficulty very well when it asks "is it necessary or justified to build"? Because every construction needs to be accepted by public opinion. In this respect, aesthetics and environment are two complementary aspects because the public will not accept structures unless they blend well into the environment. Nowadays, we are in a contradictory situation. People no longer accept the construction of infrastructures, but they demand easier access everywhere.

Must the environment be an element of a project?

The environment is a controlling factor, both for the choice of materials and construction methods. Although there are not yet any contracts based strictly on respecting the environment, there are requirements about choices of materials to be used for the construction of roads, tunnels and buildings. Many participants in the *fib* symposium discussed subjects related to the choice of materials and execution of work. They showed that environment has a direct influence on construction methods. Self-compacting concrete is a good example because it avoids

the need to compact concrete and consequently the use of large and noisy machines. Although at the moment large projects have to stop between 8:00 and 9:00 every evening, the advent of new material such as self-compacting concrete and new construction methods that are kinder towards environment could affect works organisation.

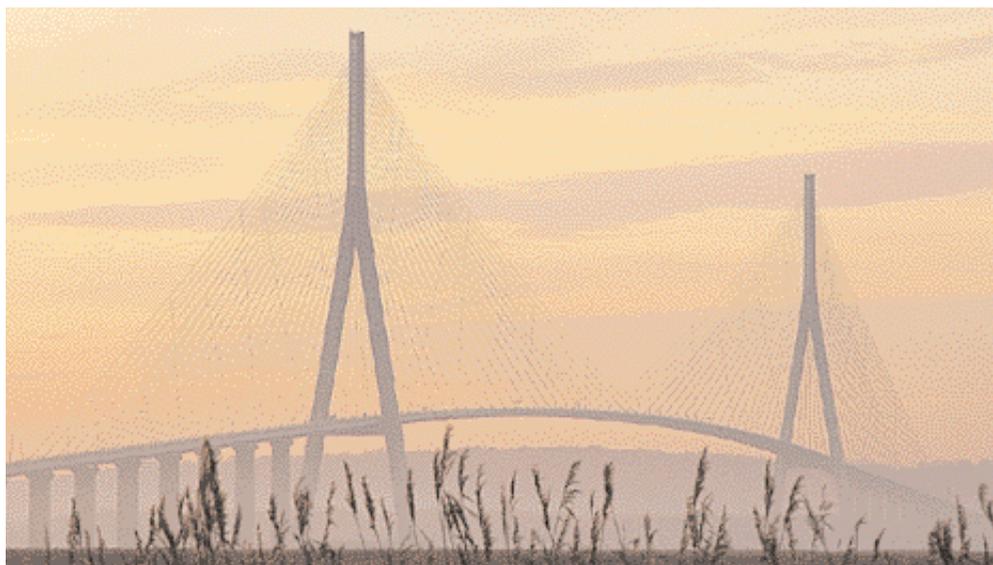
Does the environment imply durability?

Durability is the keyword of the *fib* commission 3. We are working to create models based on limit state studies, to help predict aging of a building after fifty years, or a bridge or tunnel after a hundred years and to measure concrete deterioration and micro-cracking. These models will help us to design structures in the future. This activity is very advanced in Japan and is one of the *fib*'s main lines of scientific research. For example, consider the Westerschelde tunnel in the Netherlands, for which the client had specified a life of a hundred years. The only way to achieve this was to use an empirical approach, using models and high performance materials. In short, we are more and more willing to make a commitment about the life of a project. This is well illustrated in standard EN1990 that contains a structures design table showing the safe life of a structure as a function of the loads that it supports.

The *fib* is developing more general models that will be applicable within about ten years. We also prefer to use the word « sustainability » than durability. The word is not new since Carl Von Carlowitz had already used it, but many people do not understand it. Yet, it encompasses the concept of environment including social criteria. It means a long term study to guarantee a high quality life style to future generations.

Should the environment be standardized or should a quality label be created?

The environment cannot be standardized. It is only possible to standardize materials and the use of these materials. On the other hand, as a result of computer systems, we are able to measure the integration of a structure in its environment and thus encourage debate, which is very important, and necessary because the construction modifies the landscape. Therefore, we have to attempt to find a balance between quality, economy and the environment.



"Aesthetics and the environment are two complementary aspects because public opinion will not accept structures unless they blend well into the environment."
The Normandy bridge is an excellent illustration of this.

Is construction the only business affected by the environment?

We cannot limit the concept of the environment to new structures alone. Energy saving provides a specific example. In Germany, 70% of all energy is used to heat buildings despite strict regulations fixed after 1973. In this case, protection of environment is related to air quality and therefore to lower energy consumption. The concept of the «three-liter car» in the automobile sector has now been applied to buildings, with the objective being to reach a structure consuming 30 kW per square meter a year, derived from all energy sources - persons, computers, solar radiation, etc.

Bridge repairs must also take the environment into account. Structures strengthening by adjustable and replaceable external post-tensioning tendons falls under the same logic.

Are we moving towards a maintenance market?

Not for buildings. The client should determine the life of his building and engineers should find materials necessary to guarantee safety for this period, like what is already done in agriculture. With this approach, everything (safety requirements, duration) is more modest so that structures can be renewed continuously.

This may seem surprising, but choice of materials is dictated by their life. In short, economy and cost effectiveness are the overriding factors.

What are the main conclusions of the *fib* symposium?

The *fib* has to consider technical aspects related to environment and to develop models that can be used to predict aging of structures and a more general model that will serve as a basis for debates on the environment and «sustainability». In this Symposium, we realized that problems related to the environment are similar in all countries in the world, although at different levels. We became aware that in the future, we would need to organize a debate with everyone involved in the construction industry, to find something in common between the different environment policies in force throughout the world.



Professor Joost Walraven, President of the *fib*, handed over the Merit Medal awarded by the *fib* to Jean-Philippe Fuzier (in photo), the Structure Scientific Director of the Freyssinet Group, and Dieter Jungwirth for outstanding contributions to structural concrete and to *fib*.

Turkey

The Ünye cement silo

Freyssinet built the first post-tensioned silo in Adana in year 1995. The project including a 91 m high and 22.90 m diameter silo, has drawn attention to the cement industry because of material and cost savings brought into investment decisions.

Many cement producers decided to employ post-tensioning for silo constructions in their new investments after the striking advantages demonstrated by this major project. This new era created by Freyssinet, which was an important milestone in modern engineering in Turkey, has now been entered with the successful completion of this new project. The Ünye cement silo has a storage capacity of 22,000 tons of raw material. The detailed study of applications made by Freyssinet and the excellent structural behaviour of the silo in service demonstrated that post-tensioning was perfectly feasible in Turkey.

Construction of a digester

Freyssinet has been awarded subcontracting services for the prestressing works of 6 digester tanks to be constructed within the scope of Adana Waste Water Treatment Plant.

Freyssinet participated in many similar projects such as Ankara (1995), Gaziantep (1998), and Denizli (2000) Waste Water Treatment Plant constructions.

After a logistic preparation and material procurement phase, the site installation work started in July. The six digester tanks are 22 m high and have a diameter of 21 m.

A total of 960 Freyssinet 12K15 anchors, 246 tonnes of prestressing tendons and 16,800 m of corrugated ducts will be manufactured and installed.

Canada

Sound berm retaining wall

Alva Construction Ltd. awarded the West River sound berm retaining wall project, brought in Reinforced Earth Company (Reco) because of the proven engineering experience, quality of materials, ease of construction and scheduling of materials to site. The owner is the NSDOT & PW company. The design/build situation put the contractor in the position of choosing the best system for the job. Rates attained

were recorded to be 180 m²/day at the height of the project. The backfill material was manufactured by Alva to the exact criteria Reco required to optimise the wall design. The maximum height of wall is 9.84 m, and total wall area is 2,880 m². A special feature was that the wall was double faced for aesthetics and to act as a sound berm facing the Trans-Canada highway 104.

France-Germany

Pierre-Pflimlin bridge



The deck is a single prestressed concrete box structure with variable depth and two slightly inclined webs.

The top slab width is 14.75 m. The bridge is built by cantilevering with successive segments cast in situ from abutments.

The end spans are built by cantilevering beyond temporary landings; one is located outside the area of the dikes, and the other is located in the river.

The bridge is prestressed longitudinally by internal and external cables.

Prestressing is applied by internal span cables composed of 25T15S

On June 5 1996, France and Germany decided to build a new Rhine crossing between Altenheim, Germany and Eschau, France, to relieve traffic on the Europe bridge that carries 30,000 vehicles per day near Strasbourg.

It will join the A5 motorway between Hamburg and Basel and the A35 motorway between Karlsruhe and Mulhouse.

The bridge under construction comprises three spans 121, 205 and 131 m long, for a total length of 457 m.

units, 13T15S, 19T15S and 25T15S internal cantilever cables, 25T15S connecting cables, and removable external continuity cables composed of 31T15S tendons. These tendons are arranged to leave a 0.9 m wide passageway; they are held in place using anti-vibration devices when the spacing between two adjacent deviators or spacers exceeds 45 m.

In all, Freyssinet will supply and install almost 450 t of internal prestressing steel and 173 t of external prestressing steel.

Spain

Chumberras interchange TF-5



Tierra Armada SA has just finished construction of the TechSpan® arches in Santa Cruz on Tenerife island. These structures form part of the construction of a low interchange between the TF5 motorway from the north and the TF1 motorway from the south, and comprise three segments - lines 10 and 13 each

carrying one traffic lane and line 01 that carries two traffic lanes separated by a New Jersey barrier. The structures are precast concrete arches that allow very small radii in plan. The entry and exit segments to TechSpan® arches are composed of precast spandrels associated with precast lateral retaining walls. The tunnels for lines 10 and 13 are respectively 90.2 m and 135.4 m long, and each tunnel is 3.5 m wide and 5.5 m high (outside dimensions 8.5 m wide and 5.97 m high). The line 01 tunnel is the longest at 421.3 m, and its dimensions are 10.5 m wide and 5.5 m high (outside dimensions 13.9 m wide and 7.6 m high). The depth of backfill above the keystone is 1.5 m for the first two tunnels and 1.6 m for the second tunnel. The client for the work was the Ministry of Public Works, and the main contractor was the TF-5 Group.

Belgium

Car park slab in Louvain

Freyssinet Belgium is participating in the construction of a car park in Louvain, Belgium. The original project design used precast elements. During construction of the work, it was found that the foundations could not resist the car park roof loads, and therefore it was decided to build a concrete top slab with 2-dimensional prestressing using cables composed of 1F15 unbonded strands. The slab consists of two main parts; firstly, a small entry tunnel, secondly the car park itself. The car park itself is divided into two parts connected together by couplers; one of the phases was opened to the public



in mid-August 2001. The architectural work was done by the De Gregorio & Partner Company with Aldo Rossi Associati, the general design was done by Arcade, and the prestressing design was awarded to Gamaco by Freyssinet Belgium. The main contractor was Van Roey.

Greece

Fruzi bridge

Fruzi bridge is part of a new highway, connecting Agios Nikolaos and Ierapetra. It is close to Pahia Amos on the North-East side of Crete. The client is the Ministry of Public Works, and the main contractor is Ergokat SA. It is a 3-span prestressed box girder bridge, 159.3 m long and 13.5 m wide.

It was built using the cast in situ cantilever method of construction and consists of a 71.30 m main span and two 44 m access spans. The structure is supported on two abutments and two intermediate piers, the heights of which are 45 and 35 m respectively. Freyssinet Ellas SA has been appointed to supply and install the prestressing and supply the elastomeric bearings. Both cantilever and continuity tendons are being used. These are 19K15 tendons, from 31 m to 63.2 m long. The work is due to be completed by the end of October 2001. Another bridge was built as part of the same project to connect the town of Agios Nikolaos to the smaller town of Ierapetra, with Freyssinet Ellas SA being appointed as specialist contractor for the prestressing work. This is a 2-span 74 m long and 13.50 m wide prestressed box girder bridge. It was also built using the cast in situ cantilever construction method and is supported on two abutments and a 20 m high intermediate pier. Prestressing includes cantilever and continuity tendons.

France

Asbestos removal operation



The MTS Company (the Freyssinet Group) has just completed a project aiming to remove asbestos from the room housing the flight simulator belonging to its client, Air France.

MTS treated a total of 300 m² of thermoplastic tiles and shot blasted the glue containing asbestos.

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Main characteristics:

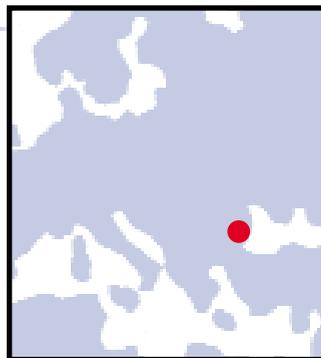
- Bridge length: 172.5 m.
- Roadway width: 7.8 m.
- Sidewalk width: 2.25 m.
- Total structure weight: 1,325 t.
- Number of stay cables: 56.
- Rotation on boom: 34 m (4 h 30).
- Rotation on barge: 250 m (6 h).
- Pushing: 25 m (7 h).

Construction methods



This bridge has a modern architectural and structural design, and is also distinctive by the innovative methods used for construction.

Putting the Cernavoda bridge into position



Freyssinet, in co-operation with its Romanian subsidiary, Freyrom, has been appointed to perform the rotation and pushing operations for the new bridge over the canal joining the Danube and the Black Sea in Cernavoda.

digest



The urban district of Cernavoda (60,000 inhabitants) stretches along the canal between the Danube and the Black sea (Canalul Dunare Marea Neagra), 190 km to the east of Bucharest. This city is a strategic Romanian site since the country's nuclear reactors are located in it. It now has a new road bridge that crosses the canal to provide the main access to the town and its railway station on the opposite bank. With its red arch, its white stay cables and its structural slenderness, Cernavoda bridge is a modern art project in keeping with the tradition of the major Romanian steel bridges built at the end of the XIXth century.

The bridge is an all-steel structure made of a deck supported by two longitudinal girders, 15 bridge segments and a multiple Nielsen type arch culminating at a height of 28 m above the road surface. When in its final position, it will be about thirty meters above the canal and will allow navigation to conform with European standards. It is supported on a 20 m high rectangular pier founded on 1.5 m diameter piles with lengths varying from 30 to 45 m, on each side of the canal. The length of the bridge is 172.5 m and its total weight is 1,325 t, its road surface is 7.8 m wide and it has two 2.25 m wide sidewalks. The bridge has a modern architectural and structural design, and is also distinctive by the innovative methods used for its construction.

Rotation on barge

The deck is built on the left bank parallel to the Danube canal. There are 56 12HD15 type stay cables (28 on each side) with individually

protected strands, inserted in a white HDPE sheath, and inclined at 60°. The method proposed by Freyssinet and its Romanian subsidiary Freyrom to bring the bridge into line with the access spans, consists in rotating the deck supported on three hydraulic jacks on a barge floating on the Danube canal supporting the front of the deck, and on a pivot at the back of the structure that acts as an axis of rotation. The operation includes three main phases, namely shifting the deck for 34 m on land, rotating it on the river for 250 m, and translating it by 25 m.

The first step is to shift the structure using TP50 jacks firstly on curved concrete beams, and then on a steel boom. It is then loaded on a 50 m long 20 m wide barge from which ballast is progressively removed to compensate for the weight of the deck. Three T15 type tendons, anchored in concrete foundations on the opposite bank (right bank), operate in turn to pull the structure sideways using SC2 1000 rotation jacks equipped with SL12, fitted on steel beams at the front of the deck; a fourth tendon acts as a holding cable.

Rotation is a difficult and painstaking operation that must allow for many natural parameters, including a high recurrent wind factor.

Rotation is applied in steps of 1 m until the final position is reached. The rotation device is then removed to leave room for a translation system similar to the system used in the first phase.

The structure is in keeping with the tradition of large nineteenth century Romanian steel bridges.

A translation of 1 325 tons

Two pairs of TP50 pushing jacks each with a capacity of 25 t are fixed to longitudinal concrete beams at the back of the bridge. The jacks are fitted with blocking shoes and move forwards along two lateral concrete beams acting as racks. The structure is supported on sliding saddles equipped with a coating composed of a polished stainless steel plate sliding on reinforced neoprene pads coated with a sheet of Teflon, to facilitate the different pushing operations. 600 t hydraulic jacks are located facing the four bearings on the underside. Translation is applied on both sides of the deck simultaneously in 0.35 to 0.4 m steps. In the first phase, the deck-barge assembly is pushed for a distance of about ten meters until the front nose of the boom lands on the temporary bearings on the left bank pier; the deck can then be pushed about fifteen meters up to the abutment. As pushing continues, the loads of the deck are transferred to the temporary bearings, so that ballast has to be added to the barge to



The bridge was pushed using two hydraulic jacks fixed to the back of the structure.

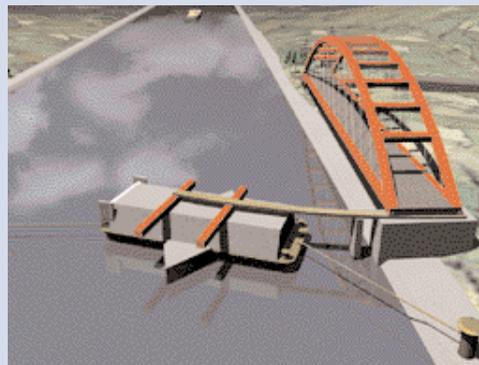
keep the structure at a constant height above the water level. Freyssinet's teams and surveyors use a computer system to closely monitor this load transfer and the geometric position of the deck. The deck will be raised to its final elevation when pushing is complete. The final step in this project consists of Freyrom's supply and installation of Tétron® bearings and road construction joints. All equipments are manufactured in Romania, in a production unit located in Bucharest.

Participants

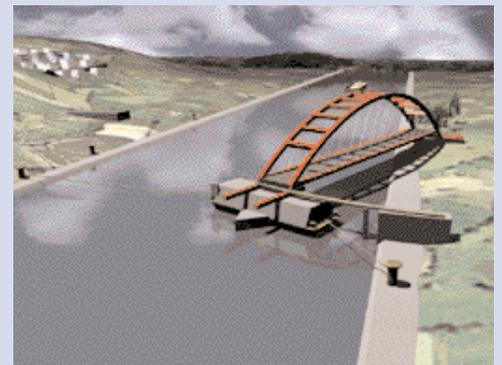
Client: SN Nuclear Electrica.
Engineer and main contractor: CCCF.
Design: Eurometudes.
Specialised contractor: Freyssinet, in co-operation with Freyrom.



Operation sequence.



Shifting the deck on concrete beams.



Rotating the deck onto the bank.



Translating the bridge on a barge.



Pushing the deck into final position.

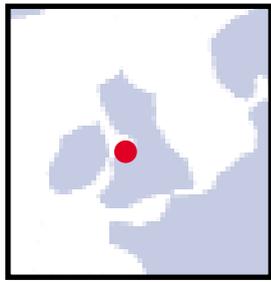


Lifting into final position.



Pushing the approach spans.

Repair and strengthening



Ashfield Bridge strengthening

The transpennine motorway bridge is being renovated, making combined use of several reinforcing techniques.

Ashfield Bridge, near Rochdale in Lancashire, carries Junction 21 slip-roads under the M62. The strength of the bridge had been assessed as sub-standard and instrumentation installed to allow remote monitoring of the structure's response to M62 traffic loads passing over it. A decision was taken to strengthen the bridge and in early 2001 the contract was awarded to Freyssinet.

Work consisted in installing steel props, which were subsequently stressed using flat jacks, relieving loads in the deck, thus allowing deck strengthening by a combination of carbon fibre and steel plate bonding. A total of 43 props were installed using 305 x 305 universal channels, approximately 3.3 m long. At the lower end the props sat on new reinforced concrete corbels keyed into hydro-demolished pockets using resin anchored strengthening. At the top of the props the new corbels could not be keyed into pockets in the existing structure, so resin anchored high-tensile post-tensioned bars were used to complement the additional resin anchored strengthening.

215 T flat jacks sat between the top of the universal channels and the upper corbel. The jacks were inflated using grout to permanently transfer load into the props and allow plate bonding to proceed. Steel plate bonding was installed on the upper surface of the deck at three locations in the M62 hard shoulder. Carbon fibre plate bonding was installed at six locations on the deck beam soffits. Both carbon fibre and steel plate bonding were designed in-house by Freyssinet. Once jacking was complete the columns were encased in concrete; a high

strength self-compacting mix was generally used, but the top 0.5 m of each column was finished off using spray concrete.

Because of the pronounced curve of the slip roads, a temporary concrete barrier was used on the outer radius during the construction phase, replaced by a permanent concrete barrier at the end of the contract to protect the new props. The confined space under the bridge and poor sight lines meant that the traffic management scheme was supervised using a closed control monitor and a recovery vehicle was on permanent standby.

Participants

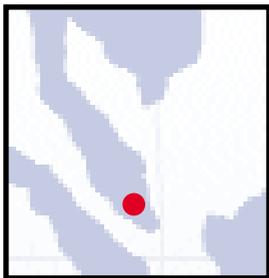
Client: *Highways Agency.*

Engineer: *Parkman.*

Main contractor: *Freyssinet Ltd.*



Construction



Cable stayed platform at Sungai Terip

Freyssinet PSC (M) Sdn Bhd is participating in the construction of a water intake platform for the Sungai Terip reservoir at Seremban, in Malaysia.

The bridge deck is a platform supporting pipes, pumps and other equipment necessary to pump water and transport it to the treatment plant. This deck is 80 m long and 15.2 m wide and is supported by stay cables anchored in a very narrow 18 m high tower located 36.2 m from the abutment, starting from the deck and comprising two parallel A frames. The structure cantilevers 43.75 m from the tower center line. The back span consists of a 20 cm thick reinforced concrete deck supported by two 45 m longitudinal prestressing beams. It is fixed monolithically to the abutment and the foundation of the pier at the other end. The transverse prestressing beams are at a spacing of 3.1 m and are supported by the two end beams. The front span of the cantilevered composite deck includes a 20 cm thick reinforced concrete slab supported by two 35 m steel beams. These beams are connected to the longitudinal prestressing beams by 40 mm diameter Macalloy bars. Transverse beams are supported on these beams at intervals of 3.8 m. The front slab is composed of 13 cm thick precast panels on which a 70 mm concrete layer is laid on a 15.2 m by 36.1 m area.

Tower foundation under 10 m of water

The structure is supported by ten type 12H15 or 19H15 stay cables, with five at the front and five at the back, in two parallel planes. The fixed upper anchors are embedded into the top of the tower and the lower anchors are connected to the longitudinal beams. The Freyssinet system uses high strength galvanized monostrand tendons with seven HDPE coated wires.



The most difficult task on this project was to make the 2 m thick tower foundation under 10 m of water in a single pour of B 50 concrete. The high pressure exerted on the walls of the 12.4 m x 12.4 m cofferdam was resisted by waterproof sheet piles driven deep into the ground using a 3.2 t vibrating pile driver. The stay cables were installed and tension was applied at the same time as construction of the front deck.

Participants

Client: Water Authority of Negeri Sembilan (JBANS).

Engineer and main contractor: Salcon Berhad.

Consultant: B.W. Perunding Sdn Bhd.

Design: MM. Wong Boon Chong and Jurutera Perunding in association with Freyssinet APTO.

Main subcontractor: Visage Engineering Sdn Bhd.

Specialised contractor: Freyssinet PSC (M) SDN BD.



Prestressing



A viaduct in the Andes

Freyssinet is carrying out prestressing work and is responsible for the supply and installation of bridge equipment for one of the viaducts part of the "Bioceánica" road.

The interocean network in South America must be improved in many countries, and particularly in Bolivia, to make it practicable in all seasons. One of these roads, the "Bioceánica" (Two Oceans) between the Cotapata and Santa Barbara districts, crosses the Real Cordillera in the Andes at an altitude of 4,650 m and drops to 980 m above sea level over a distance of only 45 km. Due to the broken relief, 20% of this section is carried on bridges. The Bolivian National Roads Service has appointed the Andrade Gutiérrez, COPESA and Minerva asociados contractors to build this road. The work is supervised by Connal and Lahmeyer GmbH and Hidroservice.

Three continuous sections

The mountainous topography makes construction of this section very difficult, and particularly the construction of a viaduct included in the project. Admittedly it is dwarfed by the grandeur of the surrounding nature, but it nevertheless reveals man's genius in building. The bridge was designed and constructed by Ingenieros Bolivianos, and consists of three continuous spans; two are 30 m long with a constant cross-section, thus acting as a counterweight to the 90 m main span. The viaduct is constructed in successive cantilevers starting from the piers and working towards the center. Its height is variable and parabolic. The first

segments are 4.5 m high and the key segment is 1.6 m high. Each span comprises fifteen 2.89 m long segments with the 0.2 m key segment being on the center of the road. This bridge is curved in plan with a radius of 135 m, and has a transverse slope of 5.5% corresponding to a basic speed of 40 km/h, and a longitudinal slope of 1%.

The cross-section of the superstructure is made of a box with a single web. The bridge is 10.4 m wide and carries an 8.3 m wide road and two 1.05 m wide pavements. The thickness of the top flange is 0.24 m. The webs are 0.25 m thick and increase to 0.4 m to accommodate the Freyssinet prestressing anchors. The two webs differ in height due to the curvature, supporting the horizontal bottom flange over all sections with a thickness varying linearly from 0.4 m at the bearing to 0.18 m at the key segment.

The entire post-tensioning is supplied and applied by Freyssinet. The most highly stressed section during the cantilever construction is on the center line of the piers due to the bending moment. In order to respect the construction calendar for the segments (7 days), the concrete must have reached the strength of 25 MPa at three days so that the prestressing force can be transferred to each segment.

The bridge comprises two - 23 m and 28 m - high piers with a constant rectangular cross-section and two webs. Each is supported on a concrete

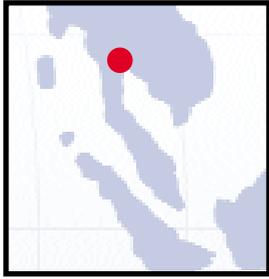


foundation anchored on six 1.4 m diameter circular piles. The abutments are supported on three 1.4 m diameter piles with variable depths to suit the ground. The diameter of all 18 piles increases to 2.4 m at their base.

This project also includes bridges with I-girders and hollow piers prestressed using the Freyssinet system.

Apart from the prestressing work, Freyssinet's service includes the supply and installation of four high capacity bridge bearings (two for each pier) and Freyssinet TECNISLID 3 GL type mechanical bearings used for the first time in Bolivia. The structure must be completed at the end of the year 2002.

Prestressing



Rattathibet bridge



Freyssinet is participating in the construction of a bridge 30 km North of Bangkok in Nonthaburi province.

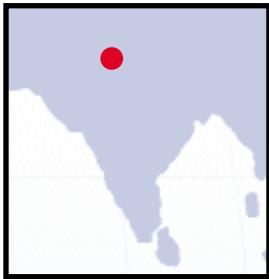
The project consists of two 140 m prestressed concrete twin structures, built using the free cantilever technique. Each comprises a 70 m main span with 3 m long segments. The main piers are integral with the superstructure that is supported on

pot-type bearings at the other piers. Freyssinet participated in the construction of the structures, and was responsible for analysing the deformation for the precamber casting curve (development of a 2D computer model), supplying and installing the pre-

stressing (252 t of 12 and 19K15 tendons for I-girders and 130 t of 12K13 tendons for balanced cantilevers) and for designing of formwork travellers and formwork of pier segments.

India

Reinforced Earth® walls



Construction of access ramps

In Delhi, the Public Works Department has chosen to build decidedly modern bridges combining the prestressing and Reinforced Earth® technologies.

The Public Works Department of the NCT (National Capital Territory) government has decided to build four flyovers and four subways in Delhi. These structures will be located at several intersections - the Ring Road and Rao-Tula Ram Marg (Moti Bagh) intersection, the Ring Road and Africa Avenue intersection, the Outer Ring Road and HR Sethi Marg (Nehru Place) intersection, and the Outer Ring Road - Savitri Cinema T-Junction.

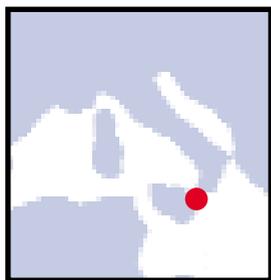
The flyovers were designed to be constructed using state of the art technology in order to save project construction time, reduce pollution levels, produce minimal disruption to traffic and incon-

venience to commuters, and optimise superior value engineering and aesthetics. The design of these flyovers is unique and they incorporate a number of features that are being used for the first time for flyovers in National Capital Territory of Delhi. These include the concept of prestressed segmental construction for the main bridge spans and the use of Reinforced Earth® technology for the approaches.

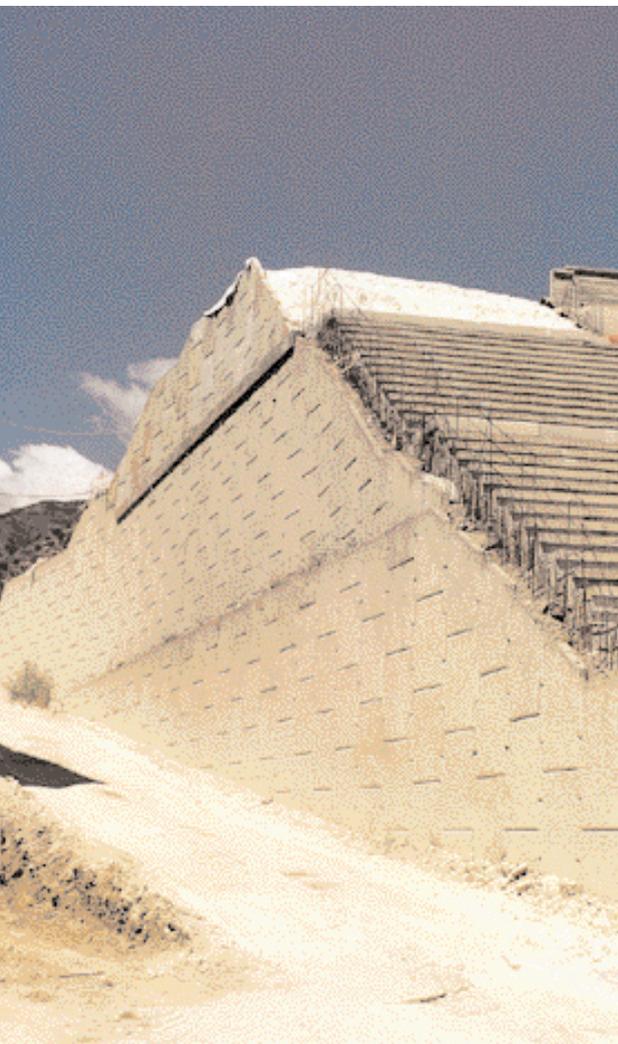
The cruciform shaped Reinforced Earth® Panels have a unique flute pattern design which was also integrated into the piers, drain covers and parapet finishes. This design was also conceived to act as multiple sound reflectors and thereby reduce

noise pollution levels. Three of these flyovers were constructed with a slope of 6%. A total of about 7,500 m² of Reinforced Earth® walls were successfully designed and constructed. Design validation was done by tests made in situ. These include: Evaluation of pullout resistance of the strips and interface friction coefficient; Evaluation of fasteners (lugs / tie-strip) connection strength and efficiency with precast concrete panels; Full-scale impact test on the New Jersey type crash barrier system proposed for these projects, and an evaluation of the structural capacity of panels under dynamic loading conditions.

Reinforced Earth® Walls



The new Messina stadium



Terra Armata is participating in the construction of the new Messina stadium, a structure inspired by the construction and architecture of ancient roman amphitheatres.

Nowadays, Messina is an important harbour city at the north-easternmost tip of the island of Sicily (270 000 inhabitants). It is located in the midst of the Mediterranean, on the Straits of Messina separating the island from the Italian mainland. The town's time of glory was in ancient Greek times, and many well preserved examples of Greek architecture still dot the surroundings. One of the most magnificent is undoubtedly the Taormina amphitheatre, built out of stone and earth, 40 km South of Messina on a hillside overlooking the Ionian sea towards Etna.

An amphitheatre in the ancient style

When faced with the task of designing a new stadium for the city, the architects could not avoid referring to this magnificent old structure. Taking inspiration from construction methods used in ancient times, they imagined an amphitheatre that would be an enormous semi-rectangular embankment with rounded corners backing onto a hillside on which concrete steps would be arranged to accommodate the public, similar to what was done by Greek architects in the IVth century before Christ, except that in the XXIst century, a stadium must also be accessible to cars, be provided with safety escapes, ramps for the handicapped, and all the other features required in modern times. An earth retaining system had to be designed to divide the earth

embankment into sections and cut passageways through it to support staircases and ramps. They chose to use the Reinforced Earth® technique. This system ensured that the main construction material, also for the retaining walls, would still be soil, thus keeping the "classical design" approach. Terra Armata, member of the Freyssinet Group, had already participated in the construction of the road between the motorway and the stadium six years earlier. It had then prepared the engineering project and supplied the materials and technical assistance for the construction of four retaining walls (with a maximum height of 12.5 m and a total surface area of 3,150 m²). The designers' choice was made considering the good results obtained by Terra Armata in this contract, in terms of design flexibility, cost reduction, speed, ease of construction and strength of the completed structure.

Reinforced Earth® Structures

A total of about 3,000 m² of Reinforced Earth® walls were designed and are now being built. Two three tiered vertical Reinforced Earth® walls (TerraClass™) were designed to cut passageways through the embankments on the east and west sides of the amphitheatre, this allows vehicles to access the site from outside the stadium. These walls will also support access ramps, stairs and part of the spectators' area.

The East side wall has a maximum total height of 21.5 m for the three tiers. The height of the

lower wall varies from 0.5 to 10.85 m and its total surface area is 780 m².

It supports the access ramp reserved for the handicapped. The intermediate wall is 0.5 to 7.5 m high and its total surface is 850 m². Its front face has many angles to provide room for the ramp turns. It also supports the stairs leading to the spectators' seats. The maximum height of the top wall is 6.2 m and its total surface is 124 m².

The maximum total height on the West side is 20 m for the three tiers. The lower wall varies in height from 0.5 to 7.5 m, and its total area is 304 m². The height of the intermediate wall varies from 0.5 to 9 m, and its total area is 470 m². The maximum height of the top wall is 5.8 m and its total surface is 110 m². This structure supports the spectators' area and provides lateral confinement to the earth embankment. Another smaller Reinforced Earth® wall (with a maximum height of 10 m) will support the V.I.P. area and will provide confinement to the earth embankment, thus facilitating access to the area itself.

An innovative design

This is not a typical Reinforced Earth® project, such as a road retaining wall. It is an architectural project, and hundreds of Reinforced Earth® front panels had to be designed and precast with the greatest care, in order to ensure the effects and the minimum tolerances required by the architect.

It was also necessary for Terra Armata's technical department to study and design dozens of construction details such as safety barriers, lightning posts, doors, etc. to be integrated into the project. The top walls of the East and West side structures also support the beams that carry the superstructure where spectators will sit. These beams are applied to the Reinforced Earth® structure as concentrated loads (permanent load 6 tons/linear meter, live load 5 tons/linear meter) as far as the top wall which was partly designed as an abutment. Terra Armata delivered a complete engineering project, including materials for wall construction; it is now providing engineering assistance on site and design advice until the completion of work.

Participants

Owner: town of Messina.

Architect: Prof. Arch. Leonardo Urbani & Ass.

Engineer: Ing. Giuseppe Rodriguez

& Ass. - E.C.S.

Geotechnical consultant: Prof. Ing. G. Umilta.

Main Contractor: Joint Venture Astaldi S.p.A.- Costanzo S.p.A. - Versaci S.p.A.

Specialised contractor:

Terra Armata Italia.



Football stadium for the Oviedo club (Spain)

The construction of the access roads to the new Carlos Tartiere football stadium in Oviedo (in the Asturias) involved the erection of a perimeter wall. This wall includes two types of structures, one with continuous faces for a maximum height of 9 m, the other divided into two parts with vertical faces for a maximum height of 18 m. The total area of the walls is 3,718 m². The second structure is composed of two walls up to 6 m high in the lower part and up to 12 m high in the upper part. This solution solved the problem of level difference between the two traffic lanes without having to build a wall at the bottom of the embankment, and maintaining the required aesthetic appearance.

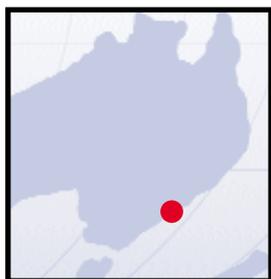
Participants

Owner: Oviedo Town Hall.

Main contractor: Dragados.

Specialised contractor: Tierra Armada SA.





Geotechnics

Innovative solution for the foundations of a restaurant

Whereas the prospect of a restaurant on one of Sydney's prime locations has unchallenged appeal, the realisation of this prospect set numerous challenges. Austress Freyssinet combined its specialist engineering skills with innovation and experience, so that with the co-operation and support of the Client, Project Manager, Architect and Engineering Consultants, this prospect became a reality.



The Sydney Ports Corporation redevelopment required a 30 m by 12 m and 4.5 m deep basement for the restaurant to be constructed within the confines of the old overseas passenger terminal building, where the natural ground water fluctuates with the tides over a range of 2 m, as a result of the close proximity to the harbour.

The site is on reclaimed land, underlain by old marine structures and wharves covered by random fills deposited over the past 200 years during various phases of shoreline development, which in turn are underlain by alluvial deposits with sandstone bedrock occurring at a depth of 17 m below ground level. The matters were further complicated as the headroom was limited to 6 m and the presence of existing inground services, old piled foundations, footings and remnant basements.

In addition, the loose and varied nature of the fill placed during the original construction of the Passenger Terminal in the 1960's made the implementation of traditional cofferdam methods such as sheet piling, diaphragm walling or battered slopes both technically and economically not viable.

The presence of popular restaurants and tourist attractions of the Rocks, the clear har-

bour water and mooring facilities of visiting ocean liners imposed severe restrictions on noise levels and environmental effects including waste disposal and working hours, to minimize the impact of the construction activities on this prime and historic part of Sydney.

Six sensitive operations

Austress Freyssinet offered a complete turnkey design and construction package including several steps, based on its own experience, its sense of innovation and civil engineering know how.

- Step 1: cross-discipline design development. In a combined effort to optimise benefits to the project, Austress Freyssinet's Civil, Geotechnical, Structural and Construction engineers worked alongside engineers from the Consultants Coffey Geosciences and Taylor Thomson Whitting Structural Engineers.
- Step 2: prestressed Freyssimix® shoring walls. In this project (considered to be a world-first) post-tensioned soil-mixed piles were constructed to form a 100 m long shoring wall along the sides of the excavation.
- Step 3: soil anchors. For the first time in Australia, geotextile socks were used with soil anchors, required in areas of unexpected poor ground. The excavation was thus completed under water.
- Step 4: prestressed concrete basement floor and walls. A waterproof prestressed concrete box was built on falsework above the excavation.
- Step 5: lowering the 850 t box. The Austress Freyssinet heavy lifting technology was used to lower the 850 t basement by 5.5 m into the excavation full of water. This strictly controlled operation took two days, at ten hours per day.
- Step 6: Bulk void grouting. Grout was injected under pressure through 44 grout outlets to fill the voids between the box and the bottom of the excavation. Immersed tremies were then used to grout the voids around the sides of the box, and the box was then dewatered before the superstructure and its fitting-out were completed.

A resounding success

These innovative techniques made it unnecessary to use alternative solutions that would have been more difficult to apply, more expen-



"The structure was constructed in a prime tourist location in Sydney and required an organization and techniques specially adapted to minimize the impact of the construction activities on the environment."

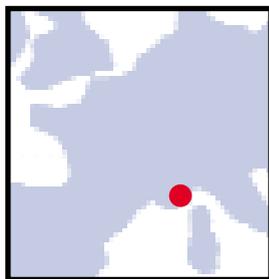
sive and more dangerous for the environment. The southern basement of the Sydney Cove passenger terminal was thus completed successfully, within allocated dead lines and within budget, thus demonstrating the excellence of the company's civil engineering activities through a wide range of design and construction activities carried out in a very sensitive public environment. This application was submitted for consideration for the Engineering Excellence Awards on behalf of all Austress Freyssinet employees and everyone else who contributed to the success of this project.



Participants

Client: Sydney Ports Corporation.
Engineer: App Projects.
Main contractor: Bovis Lend Lease.
Architect: Bligh Voller Nield.
Specialised subcontractor: Austress Freyssinet.

Soil reinforcement



Solid grouting at Nice airport

The Freyssinet South-East and Menard Soltraitemement South-East Group has just performed a soil strengthening project by solid grouting on the access viaduct to Nice airport terminal 2.



Campanon Bernard Méditerranée has appointed the Freyssinet South-East and Menard Soltraitemement South-East group to apply solid grouting treatment to sand layers in which there was a risk of liquefaction in the case of an earthquake. This treatment was applied adjacent to six piers and two abutments supporting the future access viaduct to Nice airport terminal 2. This treatment makes it possible to support the structure on surface foundations.

Grids and boreholes

The depths varying from 15 to 25 m and the thicknesses to be treated, varying from 3 to 7 m, were determined by Fondasol based on a comparison between values measured in untouched soil (net limiting pressure and SPT*) at the location of each foundation, and limit values for non-liquefaction deduced from Ambraseys formula. This treatment is obtained using primary and secondary boreholes

* Standard Penetration Test

at the location of each foundation on regular 4 x 4 m to 5 x 5 m grids, extending beyond the periphery by at least one grid line. Grouting is done sequentially on the primary boreholes, firstly around the periphery in order to form a cage, and then secondary boreholes and finally tertiary boreholes if non-liquefaction criteria are not satisfied. Grouting parameters (grid, filling ratio, pressure stop criteria, etc.) were selected at the beginning of the work during two test plates on which pressure measurements and SPT tests were carried out. This project was carried out over a two-month period, and includes a total of 6,000 m of boreholes and 350 m³ of injected grout.

Monitoring and inspection means

The solid injection process selected for this project consists of forcing mortar into the subsoil at pressures varying from 4 to 7 MPa through tubing previously driven into the ground by rotary percussion,

using sacrificial tools. Mortar is added from the bottom working up in 0.5 to 1 m passes starting from the bottom of the boreholes. With this type of treatment, internal quality control can be carried out continuously, and external quality control can be done when the works are accepted. The internal inspection is done by real time monitoring; the digital and graphic recorder installed on the drilling machine indicates the main parameters (advance speed, pressure on the tool, grouting pressure, etc.) during the drilling phase. This information is used to identify correlations with the results from boreholes made in previous investigations. The main filling parameters in the grouting phase, in other words the instantaneous flow, the accumulated flow per pass and the grouting pressure are recorded using automatic pulse counters and manometers installed on the pump and at its output. A report is produced for each foundation, containing records of parameters and filling characteristics for each 1 m segment (volume added, injection pressure at end of pass, etc.). The external check is done by Fondasol responsible for geotechnical monitoring of the work; they carry out a series of pressure measurement boreholes and SPT tests under each treated foundation. These checks are used to ensure that the liquefaction potential is eliminated. The Freyssinet South-East geotechnical team and Menard Soltraitemement (South-East branch), a subsidiary of the Freyssinet Group, have combined their know how, personnel and equipment resources (2 drilling machines, 1 double piston pump, etc.) to carry out this solid grouting work.

Participants

Client: Côte d'Azur Chamber of Commerce and Industry

Main contractor: Thalès (SODETEG).

Specialised contractor: Freyssinet and Menard Soltraitemement. Group

Vacuum® consolidation

Soil consolidation in Bangkok

The Menard Soltraitement Vacuum® consolidation solution was selected for the construction of a new electricity power station in Thailand.

EPEC (the electricity company) decided to build a 350 MW combined cycle power station to match the increasing demand for electricity in Thailand. This power station built by Alstom Power is located at the estuary of the Chao Phraya river amongst several shrimp farms 30 km south of Bangkok in the Gulf of Thailand, and is founded on 33 m long piles.

Menard Soltraitement proposed a Vacuum® consolidation solution to treat the clay under power station roads, so that the power station could be constructed on very poor soils. Vacuum® consolidation is more economic than the use of piles, and provides a means of causing early settlement of the order of several meters, leaving a few centimetres of residual settlement to take place over the next twenty-five years. The soil to be treated consists of a sedimentary layer in the Chao Phraya basin in a marine environment aggressive to concrete. These sediments are better known under the name of Bangkok clay or “Very Soft Clay”, and are highly compressible.

Vacuum consolidation

The work done by Menard Soltraitement consists of a vacuum consolidation of the Bangkok clay layer under the 2 km of internal roads in the electricity power station, namely an area of 30,000 m² over a depth of 20 m. The work to treat the 600,000 m³ of clay will last for twelve months, including six months for drying the clay layer using twenty 4.5 kVA vacuum pumps, 700 km of drains and four cranes for installation. 40,000 m² of 1.5 mm thick HDPE membrane, and 100,000 m³ of backfill will be placed. Consolidation of the clay layer will make it capable of supporting the load of the future fill for the road and traffic carried on it, guaranteeing stability and a residual settlement of less than

40 cm over the next twenty-five years. This layer must be consolidated over 2.7 m. The client could choose between two different techniques, namely natural consolidation and a simple overload for four years, or vacuum consolidation (Menard Soltraitement patent) for six months. Menard Soltraitement was chosen to perform this first site consolidation operation, due to time constraints. The anticipated settlement is 2.7 m for a 20 m thick layer. A 4.4 m thick layer of fill must be used to compensate for settlement of the clay layer and to increase settlement rates. Originally, without the vacuum consolidation treatment, the soil would have failed with only 90 cm of backfill.

Consolidation of the clay layer requires extraction of a certain volume of water from the soil in order to reduce the volume of voids in the soil; the objective is to increase the soil density until sufficiently good mechanical properties are achieved to guarantee the required residual settlement. Using its Vacuum® consolidation patent, Menard Soltraitement has successfully placed 4.40 m of fill on the Bangkok clay layer, well known as being one of the most difficult to treat in the world, without causing soil failure and obtaining the necessary 2.70 m of settlement. The Vacuum® method used by Menard Soltraitement has allowed the various participants working on the project to gain immediate access to the power station construction site despite difficult conditions due to the rainy season and the extremely soft soil.

Participants

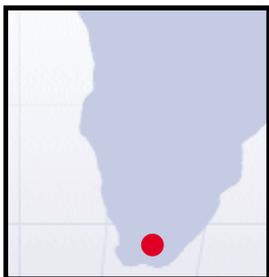
Client: EPEC (Eastern Power and Electric Company LTD).

Engineer: DEC (Dynamic Engineering Consultants) – SEATEC Group.

Main contractor: ABB-ALSTOM Power.

Specialised contractor: Menard Soltraitement

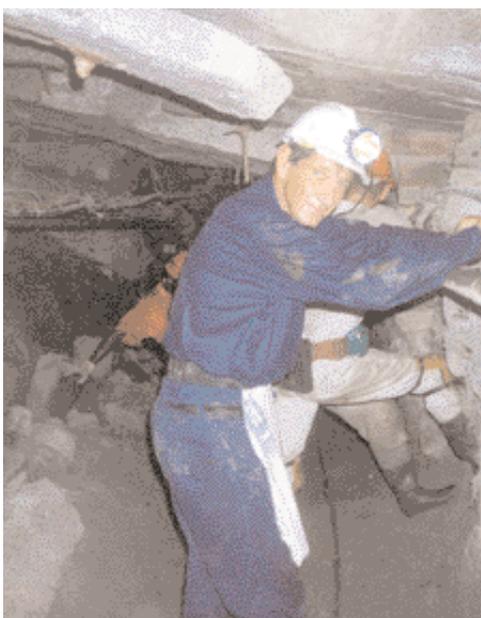




Support systems

New mine support systems

REMS and CSIR/Miningtek are cooperating to test two support products for mining tunnels, to improve gold and platinum production.



Underground gold and platinum mines, excavated in hard rock, generate about 40 billion Rands every year (1 Rand is equal to 0.15 €) of export sales. The need to provide safe supports in stopes has generated a specialised industry with an annual turnover of the order of 1.25 billion Rands, about 3% of the total sales. There are different types of support systems selected according to the specific underground conditions; support systems based on timber and precast concrete blocks, timber and steel props, cement grout blocks cast in situ and compact backfill, etc. Platinum

is usually extracted at depths varying from 500 to 1 500 m and gold is extracted at depths from 500 to 3 000 m.

Reinforced Earth Mining Services (REMS), a subsidiary of Reinforced Earth (Pty) Ltd, has been doing research and development work for several years to develop new support systems based on the principles and theory of Reinforced Earth® in order to obtain the required support properties, in other words initial stiffness under load, controlled convergence once the maximum load has been reached. REMS own patents for all their systems.

Cempak and Filpak

The REMS Company is participating in a product development program in co-operation with the main South African mining research center, CSIR/Miningtek. The program is aimed at proving and improving the feasibility and technical advantages of the two systems, called Cempak and Filpak respectively. This program is 50% subsidized by the state-owned Industrial development Corporation in a scheme known as SPII (Support Programme for Innovation in Industry). Trial underground installations of Cempak and Filpak products have already been successfully completed within the program with precise checks on loads and deflections. The results obtained up to now are promising, and the two mines in which these trials are being carried out have confirmed that they

would be interested in further larger scale trials for both products. The program was completed in August 2001. Miningtek and REMS will write a technical report and a cost comparison analysis jointly.

In the future, platinum and gold will be extracted at even greater depths to access to new and possibly richer deposits. This is the context in which the REMS products have many advantages, both for costs, safety and performance under load.





Reinforced Earth® walls

Muskeg reservoirs

Six reservoirs designed to contain bitumen have been built using Reinforced Earth® walls.

The Muskeg river mine is 75 km north of the town of Fort McMurray in Alberta, Canada. Bitumen is extracted from some sands in the region at this mine. A mixture of bitumen and sand will be excavated and then mixed with hot water to separate the bitumen from the sand in the form of a froth*. The daily production in 2002 will reach 155 000 barrels of low viscosity crude oil (or bitumen) and it will continue for about thirty years. Six

reservoirs have been built using Reinforced Earth® walls for this project. The Shell Canada Ltd Company, the Engineer, has appointed Reinforced Earth® Company Ltd Canada to design and supply the wall surfaces. The work is composed of 8,480 m² of cruciform shaped concrete panels and seventy-two top slabs (each 7.7 m long, 21 m wide and 0.7 m thick with a span of 6.6 m). The maximum height of the walls is 8.8 m. This project is an inno-

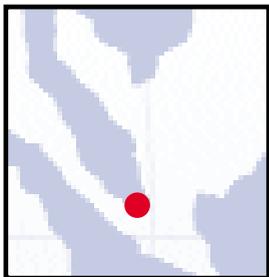


vative use of the Reinforced Earth® technology. It combines circular retaining walls and "bridge abutment" walls to support concrete roof slab support beams supported on foundations spread on top of the Reinforced Earth® volume. The six structures (two 54 m diameter and four 43 m diameter reservoirs) are used as foundations for the six tanks to be built above and that will contain the froth.

* Froth is a non-Newtonian fluid assumed to be pseudo-plastic, in other words their apparent viscosity decreases when the shear velocity increases. It is also found that this apparent viscosity increases with the froth quality.

Singapore

Carbon Fibre Fabrics (TFC®)



Strengthening of Mayten building

Mayten floors were strengthened by TFC® to satisfy needs for a change of function.

The Mayten Building is a four-storey industrial building with a basement car park and was built in 1996 on Singapore Island. Floors are made of prestressed post-tensioned concrete and they were designed and constructed by PSC Freyssinet (S) Pte Ltd, in co-operation with the consultant. The first storey consists of a system of slabs and beams and upper storeys consist of a flat slab system. The new tenant, DataOne Asia, wanted to strengthen the existing floors to cater for their new requirements. A new mezzanine floor was to be built on top of the existing first storey and an increase in the live load capacity of the second and third storeys

from 10 kPa to 16 kPa and the capacity of the roof slab from 5 kPa to 7 kPa. PSC Freyssinet (S) Pte Ltd was appointed by the initial consulting engineers to come up with a design using glueing Carbon Fibre Fabrics (TFC®). The main requirements to be respected by the main contractor were the effect of post-tensioning on the strain compatibility calculations before and after application of carbon fibre fabrics, the type of failure mode (ductility) of the structure at the ultimate limit state, and the requirement for fire protection applicable to the TFC®. TFC strips were applied mainly in areas in which the sagging moment generated tension on the under-

side of the slabs, following the arrangement of the tendons at a maximum spacing equal to six times the thickness of the slab. In general, strengthening on the top of the slabs in hogging (negative) moment areas was avoided because of the additional work necessary to remove the existing floor covering. After application of TFC® on the beam and slab soffits, a coating of fine sand was brushed over the closing epoxy coat prior to the final curing, in preparation for the surface finishing skim coat and painting to be carried out subsequently. PSC Freyssinet (S) Pte Ltd treated 1,000 m² of beams, floor slabs and roof slabs in the complete building.



In partnership with Etandex, Freyssinet is renovating the Oraison canal (France). Built in the late 50's this work is included in the river Durance development scheme. The works include surface treatment and watertightness repair along part of the canal. A site to be discovered in the next issue of Freyssinet magazine.

