NEWS

THE VSL-INTRAFOR MAGAZINE • ISSUE TWO - 2002

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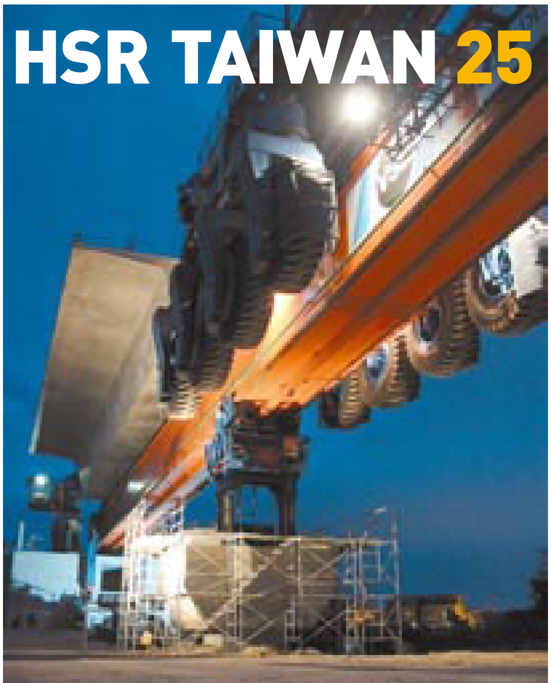
Full span pre-casting for high speed erection 25

An unusual alternative option, the "full span pre-casting" (FSPC) was mooted to build a 340km Rail Link of primarily Viaduct in Taiwan.



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EDITORIAL

BY JEAN-PHILIPPE TRIN

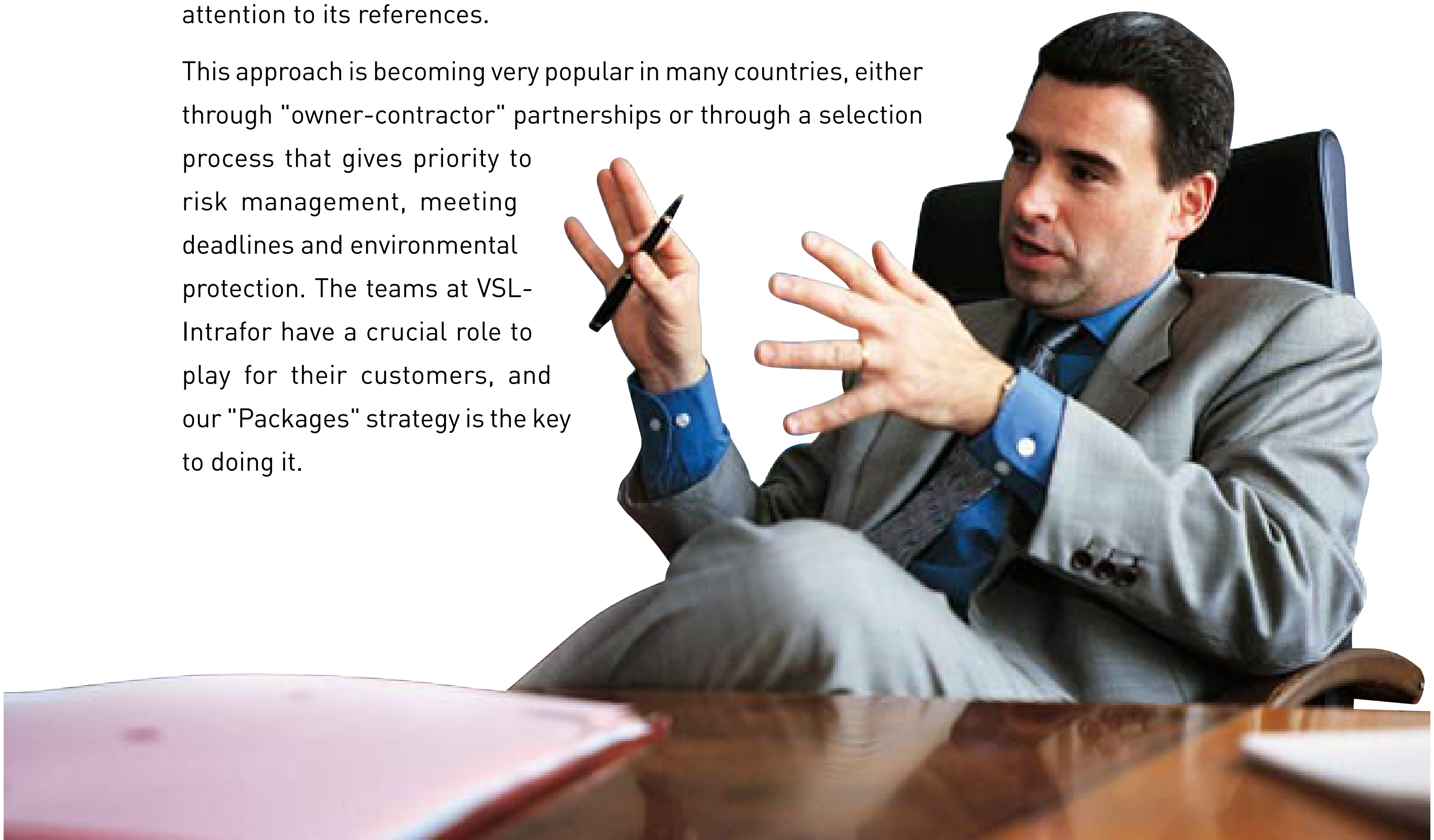
Specialist and partner

The projects that our customers are undertaking nowadays are increasingly complex in terms of technical content, scheduling and constraints, both environmental and legal.

VSL-Intrafor's engineering capabilities and many years of experience with challenging projects allow its engineers to imagine cost-saving solutions that minimise risks to the environment and cut down the interfaces that customers have to manage. Using its range of specialisations, VSL-Intrafor can offer integrated, full-service "packages" that reduce the number of companies involved in a project and offer greater assurance of meeting deadlines.

When large owners such as the KCRC (Rail) in Hong Kong award a contract, they take into account a technical rating as well as a financial one. The principle of selecting the best technical and financial bid requires that specialised companies be involved in the tender preparation phase. This gives VSL-Intrafor the opportunity to demonstrate its technical creativity and draw attention to its references.

This approach is becoming very popular in many countries, either through "owner-contractor" partnerships or through a selection process that gives priority to risk management, meeting deadlines and environmental protection. The teams at VSL-Intrafor have a crucial role to play for their customers, and our "Packages" strategy is the key to doing it.



FACTS & TRENDS

Australia

Marked out!

→ **The facilities at Lyell McEwin Hospital** in N. W. Adelaide required 16,000 m^2 of suspended floor area with 10-m spans. Authorities were reluctant to accept post-tensioning out of fear over potential collisions with tendons in coring future penetrations. VSL offered the client a tendon-marking solution, whereby the tops of slabs are marked with a single continuous line while slab and beam soffits are stenciled every 5-6 meters. ■

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VSL Damping System

Ready for action as needed

→ **VSL has developed a friction damper** to control stay cable vibrations on bridges. The VSL damper is set up to remain idle for small and non-critical vibration amplitudes, thereby reducing both wearing and maintenance costs.
VSL's friction damper is currently being used on two bridges: 120 dampers installed on the stay cables of the Uddevalla Bridge (Sweden), and 4 dampers installed in 2001 on the longest cables of the Gdansk Bridge (Poland). For the Uddevalla Bridge, which is exposed to strong winds, the friction force has been adjusted to activate the damper only when the vibration amplitude of the longest cable exceeds 70 mm.
After some two years in operation, 30 friction dampers were checked during a maintenance operation of the stays; this operation confirmed the effective damper behavior, and demonstrated the ease with which components may be dismantled and then reassembled in situ. ■

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Chile

Footbridges: large strides

→ **VSL has built a total of 15 pedestrian bridges in Chile** during 2000 and 2001 and is currently working on another 23 units in the vicinity of Santiago. Use of the post-tensioning technique in building such bridges has produced a major impact: technically and for aesthetics. The company's next step will be to improve designs for urban concessionary projects. ■

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Earthquake protection

Spider on its way

→ **"Spider" is now well on its way** to commercial application. VSL has taken an active part in the development of this project sponsored by EEC, aimed at retrofitting buildings as an earthquake protection measure. The "Spider" method consists of extending energy dissipation limits through an innovative system based on the serial coupling of damping devices and prestressed cables. The damper cable system is preloaded and transmits seismic energy from the building to the damper via a cable. The damper stroke can accommodate the displacement of each story. This system offers a promising solution in that no major additional strengthening is required and architectural constraints get satisfied all at the same time. Furthermore, it limits structural movement. ■

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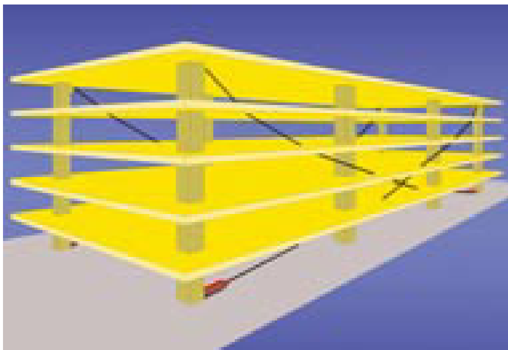

Events

VSL at fib 2002

→ **The first fib Congress "Concrete Structures in the 21st Century"** took place in Osaka, Japan, in October 2002. Approx. 80 exhibitors and 2000 visitors attended the event. VSL International held a booth displaying the SSI 2000 stay cable system and CS 2000 anchorage, and presented several papers at the conferences: Design and construction of precast concrete segmental viaducts on KCRC West Rail Project, Hong Kong (Neil Thorburn), Electrical isolation as enhanced protection for post-tensioning tendons in concrete structures (Adrian Gnaegi, Juan Ayats), Fire resistance of Ductal® ultra high performance concrete, Innovative footbridge in Seoul-Seonyu Footbridge (Mouloud Behloul), Controlling vibration of stay cable, Enhancing the curability of stay cable (Yves Bournand), Enhancing the durability of post-tensioned structures by improving the quality of grouting (Hans-Rudolf Ganz, Stéphanie Wildaert), Recent developments in the protection of prestressing steels (Hans-Rudolf Ganz). Three awards attributed for "Outstanding concrete structures" went to projects to which VSL contributed: Bras de la Plaine Bridge in the Reunion Island, Vlatava River metro Tunnel in Prague, and the TGV viaducts in Avignon, France. ■ *Contact: hrganz@vsl-schweiz.ch*

Australia

A few years in hospitals?

→ **In Victoria, Australia,** both the private and public sectors will be spending hundreds of millions of dollars in building new hospitals and health facilities over the coming years. VSL in Australia is targeting these projects and has already won two: Epworth Hospital Centre Redevelopment in Richmond, and Stage 1 of the Austin & Repatriation Medical Centre Redevelopment. ■ *Contact: ccheong@vslmelb.aust.com*

NOTE PAD

The best - *The Seonyu Ductal® footbridge constructed by VSL Korea was awarded by the Korea Concrete Institute as "the best concrete structure".*

New tech award - *VSL in Chile have been awarded the "Technologic Development Award" by the Chilean Institute for Cement and Concrete. This prize highlights features in high excellence cement or concrete activities.*

Gallery job - *At one of the terminal platforms in Paris's Roissy Airport, a site where Intrafor has been working extensively over the past five years, the company has now been commissioned to build the diaphragm walls for the 240-m long future baggage-conveyance gallery at module 2E.*

Improved version of AMS – *VSL's Automatic Monostrand Stressing System accurately stresses each individual strand to the specified load and records the data. The lift-off mode now permits to execute automatic lift-off of individual strands of a stay cable to detect and record the actual strand force.*

Enhanced reinforcement cages - *Development of the CADA software through a joint project between the Paris and Hong Kong foundation design offices now enables the computation and automatic generation of the drawings for diaphragm wall reinforcement cages on the basis of force computation results.*

ISO9001-2000 - *VSL's manufacturing plant in Hefei, China had its quality management system certification renewed and upgraded to the ISO9001-2000, including the recent bearings and joints activity. Such a distinction represents a first for any VSL company.*

Comprehensive services & packages

High skills packed togeth

The packages — combined service offers structured around a recognised speciality such as post-tensioning or foundations — are designed to optimise costs and scheduling. The success of this strategy is becoming broader. Here are some examples.

For over 10 years now, VSL has been offering customers comprehensive solutions, or "packages", structured around one of its recognised specialities such as post-tensioning, construction systems or methods. The potential scope of these packages grew even broader a year ago with the addition of Intrafor's exceptional know-how in the field of deep foundations. These packages can be put together in many different ways to provide customers with project-tailored services that will optimise costs and scheduling.

This strategy of offering broader combinations of services is a response to the complexity and inter-related aspects of a project such as post-tensioning/ reinforcement, segment erection and concrete works in operations involving ever-shorter deadlines. By giving specialists the central role in dealing with technical issues, efforts can be focused on devising effective solutions to the most complex problems and implementing them as efficiently as possible.

At the heart of the action

Whether post-tensioning is used in the construction of a cantilever bridge, a girder bridge, a segmental bridge erected with a launching gantry, ground slabs or some other project, it is always on the critical path of the work because it affects the organisation of the construction cycles and thus the overall progress of the project.

Likewise, the use of climb forms or slip forms, two other VSL-Intrafor specialities that are well adapted to the construction of very tall buildings or the pylons of suspension or cable-stayed bridges, will be a determining factor in developing the methods, defining the resources and setting up the scheduling.

When it comes to deep foundations, the erection of diaphragm walls (Intrafor's core activity for over 30 years) will affect, for example, how an underground parking facility is constructed. Managing the interfaces with the future floors takes on major significance because it offers a way to save time and materials by dealing with two issues - infrastructure and superstructure - at the same time.

At the customer's request

The idea of "extended services" or "packages" was inspired by the demands of customers - demands that arise in the continual dialogue maintained with them concerning possible technical solutions and the analysis of possible risks. The purpose of this relationship with customers is to limit from the beginning the interactions that may complicate or slow down the successful completion of a project. It also allows the responsibility for meeting the stipulated quality standards and deadlines to be placed on a single service provider. In such a relationship, VSL-Intrafor is able, if appropriate, to work as a partner with the customer, and not only as a sub-contractor. This was the case, for example, in the Puente de la Unidad Bridge project, a turnkey undertaking in Mexico executed in partnership with one of the main companies in Monterrey.

er

Optimising costs

There are many examples of VSL-Intrafor packages in projects in Asia, Central America, South America and Europe. In Asia, for example, VSL supplied a package of slip form and heavy lifting services for the construction of the towers of the Tsing-Ma suspension bridge in Hong Kong. Numerous segmental bridge decks have been built in places like Hong Kong (Hung-Hom bypass, West Rail C201/211, East Rail), Laos (Pakse), Malaysia (2nd crossing), Thailand (NS4, NS7) and recently in Singapore (the Telok Blangah bridge). In the Gateway project at Hong Kong, VSL was called on to provide a particularly broad range of services in the building construction field, including climb forms, post-tensioning, table forms and concrete works. In every case, VSL's extensive ▶

PUENTE DE LA UNIDAD: A PACKAGE FOR DESIGN & BUILD

Complete bridge supply

The Grupo Garza Ponce - VSL Mexico joint venture has been awarded, as main contractor, the "Puente de la Unidad" construction project, a 300-m long cable-stayed bridge crossing the Santa Catarina River in Monterrey Nuevo Leon (north of Mexico City). As partner to this 50/50 joint venture, VSL Mexico has been assigned a scope of works that includes project management, complete technical and methods support, and a portion of production management. VSL Mexico will also supply and install both the 220 tons of post-tensioning and 440 tons of stays using the SSI 2000 system. Structural design has been performed by the joint venture set up between SOCSA, a local company, and International Bridge Technologies Inc., a US company based in San Diego, California.

The bridge is composed of a single 60-degree inclined post-stressed pylon on the south side of the crossing, fastened onto a massive 8,000-m^3 concrete slab footing up to 5 m thick. The entire structure reaches 160 meters in height; 13 pairs of stays on the northern side have been installed to support the main deck and its four-lane traffic. The pylon is being erected along the alignment of a major highway, which has been temporarily diverted while awaiting project completion and opening of the ensuing highway crossing. The deck is composed of a 100-m long concrete transitional span, designed to accommodate two access ramps, along with a 150-m long composite (structural steel and concrete) element connecting to the northern viaduct.

This US$ 17-million project, contracted for the Nuevo Leon government, commenced in June 2002 and is scheduled for opening by August 2003. ■

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EAST RAIL KCRC: A PACKAGE FOR CONSTRUCTION METHODS

14 fronts simultaneously

The East Rail KCRC project represents a true challenge for the VSL Hong Kong site team in terms of organising an around-the-clock schedule of works. This meant accommodating erection of the segments over highways during night shifts and a constantly-changing sequencing of the works program (heavily influenced by pier availability and local traffic constraints). In January 2001, VSL HK, in partnership, signed a contract with the Necso-China State-Hip Hing Joint Venture for the construction of East Rail KCRC extensions in Hong Kong (Contracts TCC200 and 300). With an overall bridge deck length of 10,800 meters, the project includes the construction of 286 spans, built span-by-span, and 20 FCM spans erected with cranes. Overall, 4,449 segments are to be erected, stressed together with 3,210 tons of post-tensioning. The project reached a critical production peak in August: 12 erections fronts, featuring 6 under-slung gantry units, 1 overhead gantry unit and 3 sets of scaffolding systems, plus 2 erection fronts for the FCM construction were mobilized and simultaneously operating; 46 staff members and a crew of some 210 workers were involved. Completion of the erection works is scheduled for February 2003. ■

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involvement benefits the prime contractor by improving its ability to meet deadlines. In addition, having VSL supply several services means that supervision costs of a value-added business are spread out, thereby reducing their impact on unit costs.

Our business is service

In 2002, VSL-Intrafor has done the precasting and erection of 700-tonne beams on a 20-km section of the high-speed train line between Taipei and Kaoshung in Taiwan. It also continued work on the East Rail project in Hong Kong with five launching girders, constructed the Bayan Barn segmental bridge in Penang, Malaysia and completed the precasting of beams for Collins Street, in Melbourne, Australia. Packages like these are attracting the attention of companies

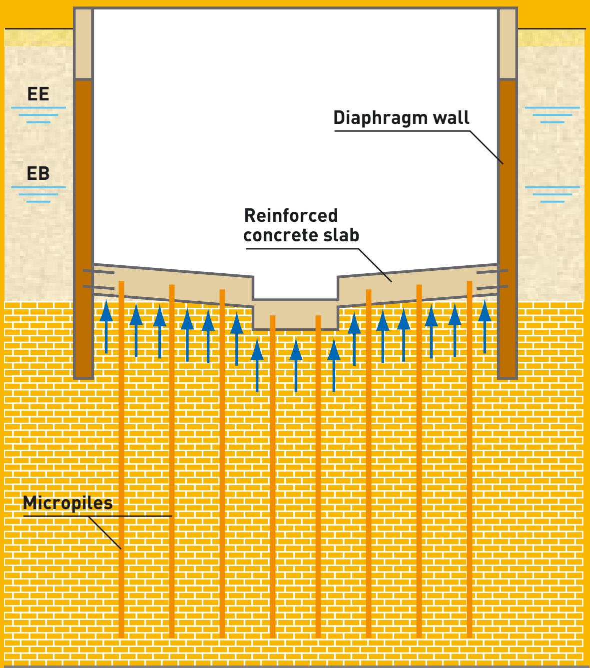
HSRL PROJECT IN TAIWAN: A PACKAGE FOR FULL SPAN PRE-CASTING AND ERECTION

Over 600 bridge spans

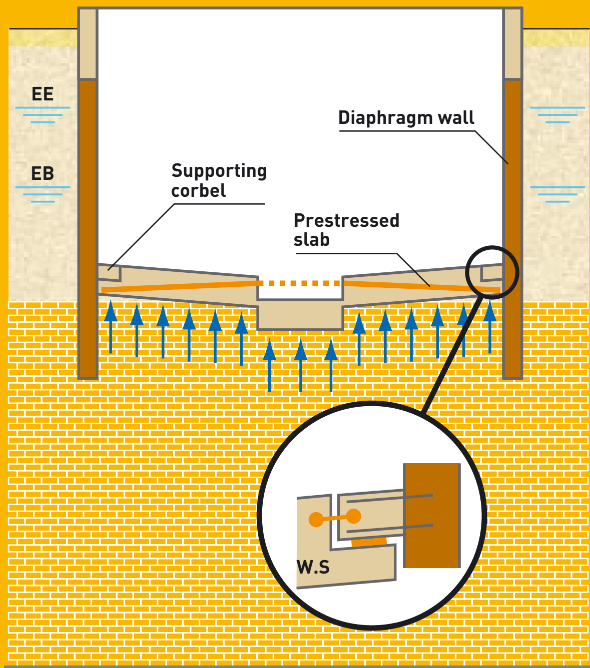
Whereas in-situ options such as cast-in-place and pre-cast segmental structures are well known in Taiwan, with multiple standard and advanced shoring systems common throughout the island, a technique such full span pre-casting promised the structural advantages of a single monolithic box girder for the double track (14m wide) plus a speed of erection faster than one bridge span per day. *See page 25.* ■

CHATEAUDUN STORMWATER BASIN: A PACKAGE FOR INFRASTRUCTURE / SUPERSTRUCTURE INTERFACE

Foundation — post-tensioning synergy



CONFORMING SOLUTION



VSL-INTRAFOR SOLUTION

Intrafor-VSL signed a contract for the construction of a retention basin measuring 22 m in internal diameter and approximately 7.5 meters in depth.
The peripheral wall consists of a diaphragm wall, whereas the basin bottom has been designed in post-tensioned concrete, owing to the fact that the slab will be required to withstand considerable loading/ unloading stresses.
The conforming solution is a circular diaphragm wall along with a conventional reinforced concrete slab 1.10 m thick able to resist uplift by virtue of an extensive system of micropiles. As a project variant, Intrafor-VSL proposed building a diaphragm wall to suit a 0.90-m thick prestressed slab (with the load transfer modification serving to up the thickness from 0.60 m to 0.90 m). This slab design relies on a corbel connected to the diaphragm wall.
To perform these works, the diaphragm 0.52 m-thick wall has been surmounted by a peripheral coping beam. The post-tensioned slab, designed as a 22-m diameter post-tensioned plate with a 3-m borehole reserved at the center to account for potential heavy cracking damage, responds in order to withstand uplift exerted on the coping beam attached to the diaphragm wall, with a water-stop system installed to ensure watertightness between apron and beam.
Post-tensioning was applied using six 6"-strand cables with a 22-meter variable length divided into two levels. This set of cables is anchored by means of passive anchorages of type "H" at both extremities and of type "Z" over the central zone.
The value inherent in this innovative variant is fourfold: increased steel and excavation quantities, reduction in slab thickness, improvement in slab watertightness (thanks to post-tensioning), and time savings due to elimination of the micropile operation... ■

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undertaking projects in Europe and across the Atlantic, such as the Brides Glen incrementally launched bridge in Ireland, the cable-stayed bridge at Monterrey, Mexico and turnkey pedestrian bridges in Chile. Expertise in soil stabilization and post-tensioning is also being combined today in the construction of industrial ground slabs in Australia, Chile and France.

This "package" strategy, which currently represents over 15% of VSL-Intrafor's revenues, is being developed thanks to the outstanding technical capabilities of the engineering offices in Singapore, Paris and Switzerland and of the Special Project teams headed by experienced professionals. Its success is reflected in the efficient technical solutions generated for clients through relations of mutual confidence, where the word "service" takes on its full meaning. ■

PACKAGES FOR STRUCTURAL MONITORING

Full-service package against ageing

Structures are undergoing permanent change throughout their life cycles: service requirements, loading conditions and physical properties of component elements. This is why VSL is developing new systems that enable monitoring the "health" and the aging of structures. VSL's monitoring strategy focuses on structures such as cable-stayed bridges, LNG tanks, deep foundations and other types of buildings. Packages include: risk analysis, functional analysis (both for determining parameters to be monitored, relevant alarm thresholds and possible corrective action). The next steps in the VSL proposal are inspection and instrumentation (for obtaining quantitative information on identified parameters), evaluation and interpretation of results, prognosis of subsequent evolution, and action proposals. Together with this "health analysis", maintenance activities are offered to provide a full service package.

These "monitoring packages" are offered as an additional VSL-Intrafor service to provide the client with value-added benefit and long-term cost savings by generating solutions that match specific needs. As an example, when sensors are intalled in order to measure critical parameters (such as loading configurations, stress, strain, temperature, displacement, inclination, vibration and fatigue loading), checking the sensor installation strategy can prove to be useful by optimising the use and the type of sensors needed.

In-house R&D have placed emphasis on durability issues, new methods, chain measurement and sensor configurations. Development analysis, testing and application tools are now provided and adapted to VSL systems. Promising results have already been achieved on various R&D projects and additional tools have been derived, thus allowing VSL to both assess the actual condition of stay cable system components and predict subsequent evolution... making a truly full-service "package against aging" available on the market.

VSL-Intrafor is also in the process of joining forces with experienced partners specialized in diagonostic tools and in predictive analysis, signal processing and management of existing structures. ■ *Contact: jbdomage@vsl-schweiz.ch*

VSL entered the instrumentation market in the 1980's with a wide range of sensors and has been offering technical assistance as well as sensor installation services. Today's challenges lie in the field of structural durability.

Interview

Jacky Mazars, formerly deputy director of the Ecole Normale Supérieure de Cachan, is a member of the board of directors of Oxand, a company of EDF Group, devoted to Risk Management of structure ageing. He is also director of the research platform "Natural Risks and Structural Vulnerabilities" (Université Joseph Fourier & Institut National Polytechnique de Grenoble, Cemagref - LCPC). He is an internationally recognised expert in structural mechanics and durability in the field of civil engineering.

What do you mean by "structural monitoring"?

It is something that is not done widely enough. For many years we put all our energy into building, with the principal aim of developing the country's infrastructures, but without considering how these structures would age. "Risk" was a term that was not used very much 30 years ago. Attitudes have changed today. Safety is at stake, and more thought is given to what will happen to these assets over time. It is the capacity to diagnose a structure's condition at a given moment. It is a bit like a medical check-up. Visual inspections are not always adequate. More sophisticated systems of measurement must be put in place.

What kind of structures does this science of structural health apply to?

First, all structures that have a long life span, such as bridges, tunnels and dams. It also concerns "sensitive" structures: that is, ones whose sudden shut-down would interfere with the normal functioning of society, such as power plants or health and public safety facilities.

How does monitoring improve structural durability?

It systematically tracks normal phenomena like the ageing of the materials - for example, the corrosion of steel or degradation of concrete. Take pure water: it can represent a danger because it absorbs minerals. By dissolving the constituents of concrete, water makes it less resistant. If, in addition to these normal phenomena, your structure is subjected to excessive loads or even slightly shifting ground, damage can occur and accelerate ageing process.

"Every functional aspect of a bridge should be monitored!"

What is the market for this type of analysis?

Contracting authorities benefit if their structures last as long as possible. Maintenance and monitoring are crucial to making sure that everything goes well. Ideally, the monitoring devices should be incorporated in the structure when it is built. We are coming around to systems similar to those installed in recent automobiles that allow garage mechanics to get data on a vehicle's vital functions simply by connecting it to a monitor.
However, besides the risk associated with "classic" durability, there is the whole area of accidental risk related to violent shocks, natural phenomena, explosions and so on. Risk is a field of knowledge that needs to be developed.

How can the additional cost of this monitoring be recovered?

In an area where seismic risk is moderate, protection for building amounts to only 5% of the total building cost, if it is taken into account at the time of the construction. It is nearly marginal. As for existing structures, for example, the University of California, Berkeley, has started a programme to strengthen all its buildings to make them earthquake-resistant. Cost is about one quarter or one-third of the value of the property! Another example is the highway tunnels. Improving air circulation keeps the air fresh, but also slows down structural ageing due to the combined attacks of exhaust fumes and humidity. Monitoring in this case can substantially increase the life span of the structure, perhaps as much as doubling it! Dealing with this sort of problem calls specialists, who stay abreast of engineering requirements and research. Sophisticated forecasting tools call for interpretation and the integration of probability brackets.

What makes VSL well qualified in monitoring services?

VSL has a strong background and long-standing reputation in post-tensioning, reflecting extensive knowledge in a high-tech area of the construction industry. Post-tensioning is a very special business. By analysing feedback data from past projects, it can take into account the future evolution of structures as of the design phase. A construction company that naturally gives serious consideration to the way structures will change over time definitely has a "culture of monitoring". That is why it is well positioned to be a leader in the trend toward monitoring durability and risk. ■

SITE INSIGHTS

Hong Kong
Ever deeper and higher!

→ **Foundations are now well on their way in Package 7** of Hong Kong's Kowloon Station development project, whose foundations system design and construction was awarded to Intrafor in a joint venture in January 2002. This 102-storey office-hotel tower, developed by Sun Hung Kai Properties Limited, will be one of the tallest buildings in the world. The foundations are composed of a 76-m circular diaphragm wall shaft, 297 barrettes up to 100 m deep and a composite bentonite-cement / sheet-pile perimeter wall. The diaphragm wall is now standing and 2/3 of the barrettes have already been cast. In order to complete construction within the tight contractual period (20 months), seven cranes and three hydromills have been deployed on site. Among the extensive equipment involved in this project is Intrafor's brand-new BC40 cutter. Daily excavation has reached an average of about 450 m^3. A fully-computerized grouting container is also being used by Intrafor to perform shaft grouting, one of the key elements to the development plan. ■ *Contact: ronan.hasle@hk.vsl-intrafor.com*

Spain
PT silo in Almeria

→ **In order to increase the storage capacity of a silo** 30 m in diameter and 40 m high while complying with environmental regulations in effect at the Carboneras cement plant in Almería (southeastern Spain), Holcim opted for a post-tensioned silo with a steel roof solution.
The post-tensioning has consisted of 70 horizontal rings with 12/0.6"-strand cables alternating over 90º, 132º and 180º within the first 6 meters and then over 180º throughout the remainder.
This configuration thus gives rise to 4 buttresses 75 cm thick. The centre to centre spacing of the horizontal cables in the wall increases with height to enable stressing all cables to the same 230 t foce, by that fully optimizing all anchorage components.
Silo walls are supported on 188 BS-type guided Stronghold bearings and include a 4x4 m door for maintenance purposes; the walls were slipformed (by CTT-Stronghold together with GBG) over a 20-day period. The steel roof was lifted in conjunction with the slipforming operation, thereby reducing overall construction time.
■ *Contact: e.palos@vslsp.com*

Australia

From brickpit to suspended floors

→ **Sydney Park Village is a large low-rise residential project** of 229 units located immediately south of Sydney. The site served previously as a brickpit, then as a landfill, required an innovative foundation solution. This was a 600-mm thick post-tensioned basement raft slab partially supported on steel piles at variable spacings; tendon units were 6-5 in two layers and two directions. A total of 101 tons of post-tensioning was required over a 6,600-m^2 surface area. VSL was also awarded the project's suspended floors component (26,300 m^2). Following the contract award, VSL was requested to produce final drawings for initial pours and mobilized on site within 2 weeks. ■

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NOTE PAD

Calling on VSL *- VSL in South Australia was nominated as a subcontractor for the JP Morgan Australasian Call Centre construction project. This structure utilizes composite beams. Steel shear studs were welded onto steel beams for integration with the concrete slab.*

Former quarries *- As part of the new "Olympiades" station for the metro line in Paris, Intrafor is consolidating former underground limestone quarry sites and backfilled former surface quarries via gravitational injection and treatment injection, hence a total of 13,300 meters of perforation and 2,660 m^3 of injections.*

Full encapsulation *- On the Inner City Bypass project in Brisbane, VSL is drilling, supplying and installing 47 fully-encapsulated permanent anchors to act as a buoyancy restraint at the middle of the ground slab.*

Large VSoL® *- On the Port of Brisbane Motorway project, VSL has been contracted to install 1,680 m^2 of VSoL® walls varying in height from 6 to 11 m. The panels used are 2.4-m square.*

Safe and sound *- VSL Dubai has been subcontracted to supply and provide technical assistance for post-tensioning works on the Tareeq Sarie Highway Project bridge structures in Jubail, Saudi Arabia. As a result of VSL's sound performance on the project thus far, Phase 2 of the Tareeq Sarie contract has also been awarded to VSL Dubai.*

Vietnam

Wagons lined up to reline a tunnel

→ **Repairs on the Hai Van Pass Railway Tunnel renovation project** have now entered the construction phase. These works entail demolishing the existing tunnel lining, composed of both concrete (vault) and masonry (walls), and then securing the excavation left open with rockbolts and shotcrete. A complementary shotcrete layer for filling voids is to be applied and a waterproofing membrane installed, using 3 layers of shotcrete covering reinforced with either wire mesh or fibers. The repair works include construction of this new structure over a total length of 670 meters as well as renovation of the four tunnel entrances. Two working trains comprise 11 special-purpose wagons to be sequenced depending on the production cycle and split into several units working simultaneously in diffrent areas. Operations are conducted over a short possession time span lasting 6 hours. VSL France, in partnership, concluded this contract late last year with Vietnam National Railways (VNR) for the renovation of 4 railway tunnels within the Hai Van Pass region, close to the city of Danang in the middle section of the country. These tunnels, part of the strategic north-south railway link between Hanoi and Ho Chi Minh City, had suffered from aggressive water penetration, exposure to climatic conditions and aging. The project is scheduled for completion by the end of 2004. ■

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Australia

The tallest VSoL® for Mount Arthur

→ **As part of a major BHP-Billiton coal development,** VSL-Intrafor completed a large-scale dump hopper structure in March 2002 for John Holland Pty Ltd.
The scope of works included the design of two VSoL® hopper structures and the supply of both 3,300 m^3 of facing panels and 220 tons of reinforcing mesh and components. These VSoL® walls represent the tallest ever installed by VSL-Intrafor in the Australasian region: 22.6 m.
VSL also offered the full range of architectural facing elements for this job. ■

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Poland

New profile for 400 beam ends

→ **For the car park underneath the Auchan shopping center in Warsaw,** the existing support structure of the beams does not allow for sufficient dilatation.

The solution designed by VSL's Technical Center Europe allows the horizontal slab movement by means of creating a gap between beams and columns and installing bearing pads under the newly corbel-supported beams. The load gets transferred from existing corbels to temporary supports equipped with jacking units. The existing corbels are then sawed and removed so as to provide a 10-mm gap between beams and columns. Beam-ends are subsequently strengthened and re-profiled. The new corbels, made of two precast "C"-shaped concrete elements, are fitted to the column with post-tensioning bars, followed by installation of the bearing pads. The load is then re-transferred from temporary supports to the columns. These works, which encompass repairs to 57 columns and 400 beams, will be completed by the end of November 2002. ■

Contact: gs@vsl-pl.it.pl

Hong Kong

Heavy duty compaction for Disneyland

→ **A large-scale land reclamation project** (200 hectares) is being conducted by the government of Hong Kong SAR at Penny's Bay on Lantau Island for the construction of the new Disneyland amusement park. Stage 1 started up towards the beginning of 2001 and is scheduled for completion by the end of 2002. This large reclamation undertaking involves: the removal of soft soils from the seabed by dredging (42 million m^3), placement of sand fill on the dredged seabed (67 million m^3) and compaction of the sand fill (40 million m^3). Dredging and placement of sand fill are being undertaken by Hollandsche Aanneming Maatschappij BV (HAM), while sand compaction and testing lie within Intrafor's scope of works. The vibroflotation technique (heavy-duty vibrating pokers for in situ sand compaction) is used by Intrafor in order to meet requirements in terms of strength and settlement. The sand fill is placed 15 meters above water level to provide a temporary load of 4 m above the finished level, with vibroflotation works being carried out from the top of the load to depths reaching 38 m. The quantities of sand to be compacted, along with the extremely heavy equipment involved (up to 16 rigs working 24 hours a day), make this project one of the largest vibrocompaction jobs ever taken on. In october, a new contract to carry out 10 000 stone columns has been awarded to the JV.

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Philippines

Cebu project nearing completion

→ **After a 6-month delay in 2001 due to local political hurdles,** the final precast girder on Segment No. 3 of the Cebu South Coastal Road Project was cast in July and erected in August. The parapet railings are due to be completed by December 2002, some 3 months ahead of the contractually-stipulated target date. This program compression was achieved thanks to the close working relationship and coordination between VSL and Taisei Marubeni Joint Venture. The project, a 1.4-km long x 16-m wide bridge over water with a typical span length of 35 m, had begun in September 2000. VSL's assigned contribution was divided into 5 subcontracts that incorporated the structure from the coping beam level upwards. Overall, this scope represents some 8,700 m^3 of concrete, 2,725 tons of reinforcing steel and 470 tons of post-tensioning. The project also provided VSL with the opportunity to introduce Honel expansion joint technology in the Philippines.

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Czech Republic

Two-bridge slide in Prague

→ **VSL Systemy (CZ) s.r.o. is providing incrementally-launched technology (ILM) in the construction of two bridges** on the Hlubocepy-Barrandov tramway track in Prague. ILM technology had not been used in this region for several years. Bridge construction by means of this method is basd on segmental deck production in a casting yard located in front of the bridge abutment. The deck is pulled out of the casting yard after particular segment tensioning. The bridge is incrementally launched on supports, that are equiped with lateral guides and sliding bearings. A steel nose is fixed at the front of the deck to reduce the bending moment o the first segments.VSL Systemy (CZ) s.r.o. is participating in both designing the casting yard and detailing the launching method to be used. The system relies on braking as well as pulling units. VSL's responsibilities include overseeing deck-sliding operations (two bridges launched simultaneously) and performing the post-tensioning works. ■
Contact: jbesta@vsl.cz

Portugal

High-tech response for the Europa Bridge

→ **For the Europa Bridge project in Coimbra,** which includes 13 distinct bridges and viaducts, VSL is supplying 750 tons of post-tensioning and 400 tons of stay cables. The main bridge extends 329.4 meters in length, with one 186.5-m span and a total of 67 precast segments. The stay cables have been categorized into 19 principal pairs and 9 retention pairs, ranging from 6-55 to 6-31 tendons and then from 6-91 to 6-37 tendons (for rear stays). All active anchorages are to be installed on the pylon. On this job, VSL is using individual galvanized and greased strands (protected by means of HDPE stay pipes), individual tensioning, replaceable strands, an external tightly-extruded HDPE coating pipe with helical ribs, and vandalism protection on both deck anchorages and retention blocks.
■ *Contact: Carlos Correia (ccorreia@vslsistemas)*

Germany

For stiffness

→ **The fixed Rostock crossing project through the mouth of the Warnow River** is drawing to a close. VSL Germany provides the supply and installation job for 150 tons of bonded post-tensioning in the tunnel structure and 50 tons of post-tensioning installed at three bridges crossing the tunnel approach roads. This submerged tunnel consists of six elements and two portals. Each element

comprises eight sections 15 m in length. In order to provide the necessary stiffness while the 120-m long elements are being floated into position, the eight sections are longitudinally stressed against one another. Once an element has been correctly located, the tendons are cut at the seven construction joints, allowing for small rotations of the sections. As a chain, the entire element can then settle smoothly onto the riverbed. ■
Contact: vsl-syst@t-online.de

Morocco

First beam

→ **In August 2002, VSL lowered the first beam of the Laayoune Wharf restoration project.**
This project represents 2 M€ and 2 years worth of business to provide technical assistance and heavy lifting services for some thirty prestressed concrete beams, each measuring 45 m in length and weighing 110 tonnes. ■ *Contact: jean-claude.peslier@fr.vsl-intrafor.com*

Ireland

Dublin port project delivered

→ **This underground highway for the Port of Dublin tunnel project,** the Mowlem-Piling - Intrafor consortium (in partnership with Mowlem and Irish Co.) installed between June 2001 and August 2002 more than 50,000 m^2 of diaphragm walls (1,200-1,500 mm in thickness). Given the very poor quality backfill, black clays and a limestone substratum with inconsistent strength, adaptations to both tools and methods were required: most diaphragm wall sections had to be excavated using cable-driven buckets with 4 stations operating during peak shifts. A cutter was activated on a section where the intrusion of stronger limestone (Rc → 100 MPa) had reached 8 meters. This exceptional project - comprising a 52-m diameter shaft excavated over 32 meters and two hatches 400 and 350 m in length - was executed without interruption over a 15-month period and mobilized up to 25 Intrafor staff members. It is the first large european infrastructure project for VSL-Intrafor to be delivered, the next one beeing the huge Groene Hart project. Both show the group's capacity to work in all types of ground, from very hard to very soft. ■

Contact: daniel.altier@nmi.dpt.com

Chile

Slabs for El Golf

→ **The El Golf 2001 project** offers a total surface area of 58,000 m^2, split into 7 underground levels and 22 upper levels, and represents one of the year's largest in Chile. It is located in one of the most upscale areas of Santiago adjacent to two other VSL post-tensioning projects: Banmedica (1995) and Isidora 2000 (1999). All three of these projects have involved the same teams (client, architects & engineers, contractor). At the end of last year, VSL Chile began promoting the VSL-bonded post-tensioning slabs using the system developed in VSL Argentina, which is basically the monostrand anchor S5N, with a single polyethylene duct. An excellent track record from past projects convinced the client to approve the new bonded system. ■

Contact: aavend@vslchile.cl

NOTE PAD

Technical lineup - *For the execution of 276 piles on the A4 motorway near Paris, Intrafor has simultaneously implemented: dry boring, cased boring by vibratory driver and dry boring with permanent casing; cased boring by vibratory driver and dry boring with temporary casing extracted upon completion of concreting; and dry-cased boring using oscillator with casing removal upon completion of concreting.*

Bayan Baru - *For this viaduct project, VSL Malaysia will erect 37 precast spans for the main viaduct and 18 for the ramps. Completion planned for mid 2003.*

Over the Neva - *VSL has been awarded the technical assistance and supply/ installation of the stay cables system on the Neva River Bridge in Saint Petersburg for Mostootriad 19, a new VSL client in Russia. Installation of the stays (600 tons of strands) will start in April 2003.*

Specially for gas - *On the Dahej LNG tank in the Western State of India, one of the first projects under the ownership of Petronet LNG in India, VSL is supplying PT materials, horizontal and vertical tendons, all PT equipment and technical assistance plus site supervision.*

A first in Vietnam - *VSL was awarded by Sumitomo Construction the installation of 234 tons of SSI 2000 stay cables for the Kien Bridge, the first precast segmental stay cables bridge in Vietnam.*

France

Innovative analysis applied to tunneling plugs

Within the scope of the Paris western bypass project (A86 highway), VSL-Intrafor acts as authorized representative of a consortium contracted to build a diaphragm wall box (155 m x 23 m x 23 m). This structure is to serve both as a breakout shaft for the 11-m diameter tunnel boring machine (TBM) operating north-to-south then south-to-north and as ventilation shafts for tunnel sections already placed into service. Two ground treatment breakouts ("plugs") have thus become necessary to support the ground mass and withstand the pressure as the TBM rises to the surface inside the structure. These plugs, made of 1.50-m thick cement grout pavement, were designed by VSL-Intrafor using a truly innovative computation method.

While the technical sizing specifications (e.g. 3-MPa minimum simple compressive strength) were imposed by the client, the computation method was left entirely up to VSL-Intrafor. Since the plug turns out to be a solid element, conventional software applications for sizing structural supports could not be adapted. A simplified approach based on material strength formulae (which consider the plug as a rectangular plate resting on its circumference) was also feasible, yet this approach would have led to excessive plug thickness.

The VSL-Intrafor foundation design office proposed a sizing procedure that entails a finite element computation program for modeling the ground with a multitude of small-sized (mesh) elements in order to study each element's individual behavior.

This computation procedure thereby enabled: validating the compressive and shear stresses in all possible cross-sections; estimating the displacements and settlements at any point; and incorporating successive project stages throughout the entire service life of the plug. The thickness was determined so as to ensure that the plug remains fully compressed when exposed to various applicable loads (i.e. thrust of earthen material, TBM thrust upon arrival, deadweight). The solution proved to be elegant, reliable and a more economical means for solving a rather complex problem. ■

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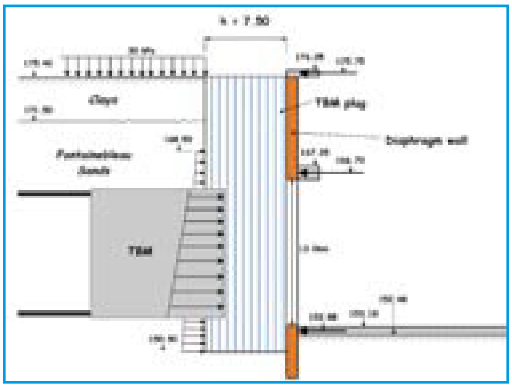
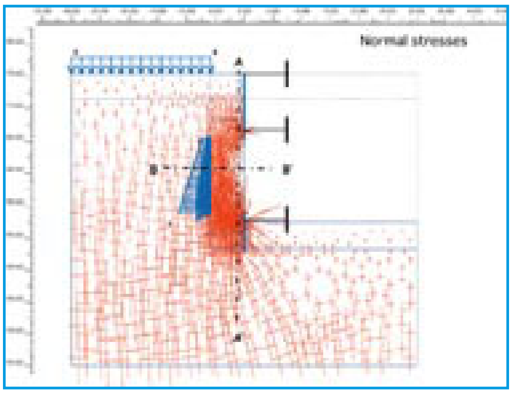
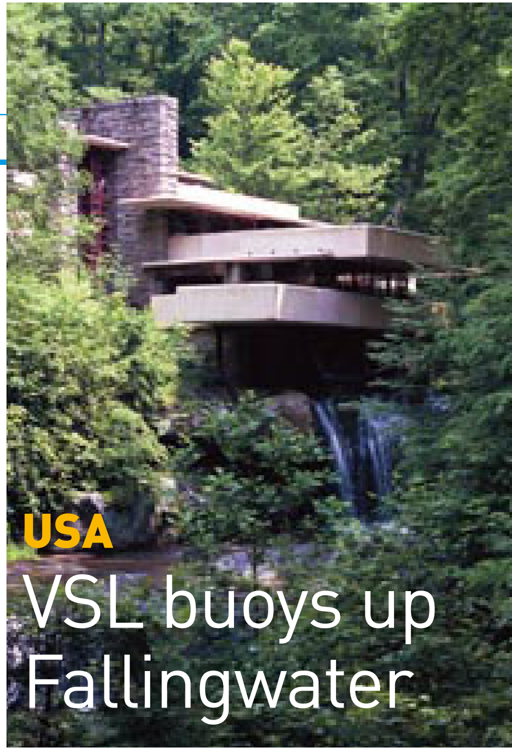


Model mesh and normal stresses: stress concentration in the vicinity of the diaphragm wall opening and formation of a compression arch in the plug.





USA

VSL buoys up Fallingwater

In October 2001, VSL was selected by the Western Pennsylvania Conservancy to perform the restoration work of both the master bedroom and living room cantilevered terraces of Frank Lloyd Wright's historic Fallingwater. Designed in 1935 and completed in 1939, Fallingwater is recognized as one of the most unique houses ever built in America. The Fallingwater renovation plan recognized the need for strengthening as well as concrete repair. Special attention was required during construction to prevent damage to the architectural features and landscaping. At the main terrace level, strengthening involved bonded post-tension tendons parallel to the cantilever girders and unbonded tendons in the transverse direction. The strengthening plan also called for steel members to be bolted to each side of the master-level concrete joist directly above the four 'T'-shaped mullions. In addition, VSL repaired and strengthened the master-level parapet walls. In respect of Fallingwater's pristine setting, restoration and repair activities were conducted with great care to minimize environmental impacts on the stream, the falls and the site's landscaping. The VSL technology solutions employed herein included both monostrand and multistrand cables. ■

Contact: bgallagher@structural.net

The Netherlands
Challenges piling up!

→ **Initiated in 2000, the 8-km long Groene Hart tunnel project** on the Dutch high-speed rail line has provided Intrafor with the opportunity to undertake some exceptional structures in a new national market and under most challenging soil conditions (peat, loosely-compacted sand, etc.) within a heavily-protected zone.
The overall works program contains both diaphragm walls (53,900 m^2) and slurry trench piles (38,100 m^2) and calls for creating two tunnel access hatches and three ventilation shafts. The northern hatch and two of the ventilation shafts have already been completed using the so-called "Soil Mixing" process.
The installation of slurry trench piles with prefabricated low-levelled piers represents another VSL-Intrafor company innovation (see News Magazine issue 1, 2001). Designed by the Intrafor methods office, this tremie concrete technique can be applied on sites where more conventional pile-driving solutions, are impossible due to depths involved. Intrafor used the "Jet Grouting" technique on several structures (over 1 500 linear meters in all). Intrafor has also earned the VCA certification for site safety.
Work on the final ventilation shaft (Bent) is underway and the long and deep Southern hatch is scheduled for completion next spring. ■
Contact: gerard.kilidjian@fr.vsl-intrafor.com

Ireland
Dublin's Golden Gate

→ **For the Taney Bridge in Dublin,** an alternative design for the main deck is based on units to be cast like shells, leaving the center devoid of any reinforcement or concrete and keeping the weight of the deck during construction to a minimum. VSL, which provided input to develop this alternative, is also supplying and installing 52 SSI-2000 stay cables. ■
Contact: jcampbell@vslsystems.co.uk

Australia
Terragong Swamp Bridge

→ **The ongoing Terragong Swamp Bridge project,** located approximately 150 km south of Sydney and extending 942 meters in length, is part of a bypass to redirect coastal highway traffic. Constructed over swampland, the 23.1-m wide, 30-span bridge essentially consists of a low-level viaduct with short spans to minimize foundation loads.
VSL's scope of works encompassed post-tensioning of 3 spans.
In order to provide for enhanced continuity/cost savings, the 41 m-long main span has been supported on "V" piers.
The two legs of the "V" were temporarily tied together with 40-mm diameter VSL HR stressbars. ■
Contact: bhannan@vslsyd.aust.com

SPECIAL REPORT

Foundations for the Museum of Primitive Arts in Paris

Noise-free, vibration-free excavation


Wall excavation


Excavation along the abutting structures


A typical audiometer


An exceptional site

Environmental protection concerns raised during building projects, as regards neighbors, the subsoil and the structure itself, have been taking on increasing importance for project owners. The deeply-embedded foundations for the Museum of Primitive Arts in Paris have asked for special measures to limit both noise and vibrations.

Fact sheet

Project owner: *Etablissement Public du Musée du Quai Branly, Paris (Quai Branly Museum Authority)*

Project Architects/Engineers: *A.J.N. - Jean Nouvel Architect (Representative), INGEROP, O.T.H.*

Diaphragm wall: *18,409 m^2, consisting of 116 panels from 500 to 1000 mm in thickness*

Grout wall: *990 m^2, minimum thickness: 0.52 m*

Piles: *32nos 800-Ø units, 22nos 1,000-Ø units*

Paris's Museum of Primitive Arts, represents France's first major State-sponsored project under the nation's new five-year presidency. The structure is to be located near the Seine River in the vicinity of the President's Office annex and of a number of the city's most prestigious avenues. Last but not least, near the Eiffel Tower. Within such a setting, the various basement levels of this building require undertaking specific works to ensure the utmost in environmental protection.

This deep foundations contract includes: a peripheral diaphragm wall 735 meters long and up to 32 meters high; a watertight, definitive plastic wall 520 mm thick; a series of 1,000-mm diameter bored-molded foundation piles, "protective" piles driven using a continuously-operating 800-mm diameter auger; pumping shafts for both draining the enclosure and monitoring the plastic wall; definitive pressure-relief drains to protect against excess water table pressure in the deepest zone; and a shoring system to hold the walls (weighing approx. 150 tons) in place.
This building program also encompasses a portion (18,000 m^3) of the earthwork required to install the corresponding infrastructure.

A prestigious address

The key difficulty in performing these works pertains to both the buildings along the famous avenue de la Bourdonnais and the President's Office annex next to the museum structure. Consequently, diaphragm wall deformation thresholds were established.

After adapting the supporting wall for stiffness (thickness-reinforcement) and connection and then phasing the works program, a 30 to 50-kN/linear meter prestressing force is to be applied on selected floor supports, which vary from one cross-section to the next. In addition, the diaphragm wall layout has been offset with respect to the plain of the buildings, as the inclined part of the museum will be supported by 700-Ø piles driven prior to diaphragm wall excavation using a continuously-operating auger. A flat coping beam serves to join at the head the diaphragm wall and the piles, whose embedment overlaps.

Mandatory warning thresholds

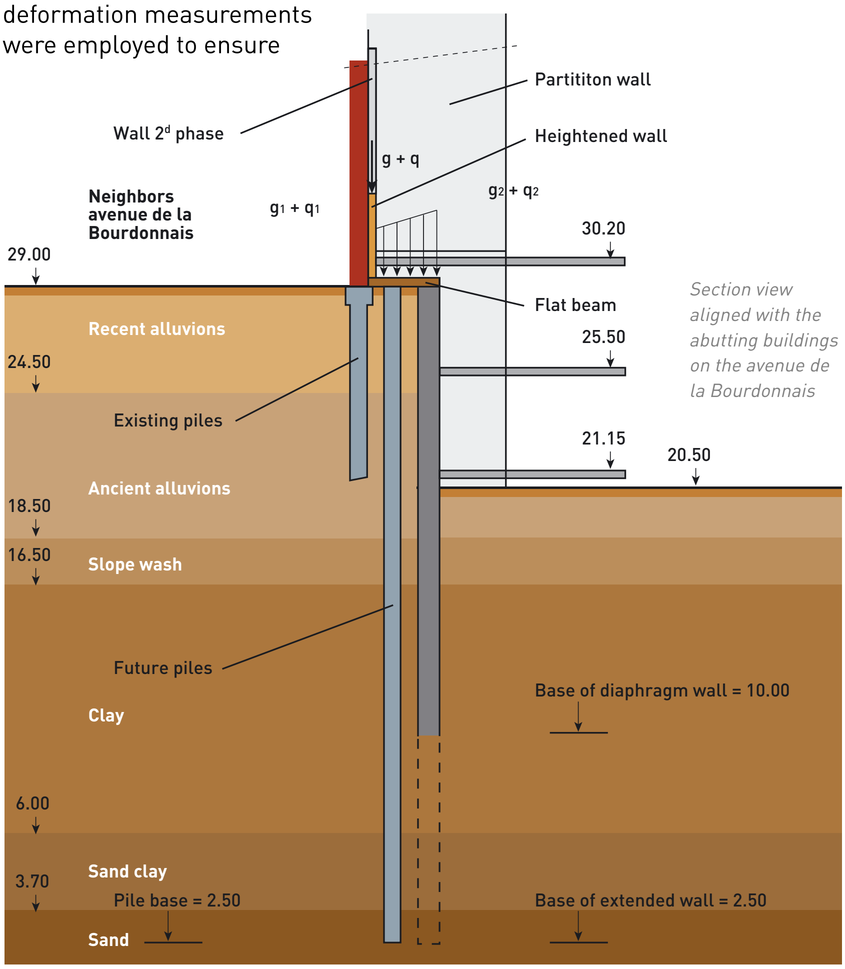
Due to the project's abutment on a number of structures, once the works got underway regular deformation measurements were employed to ensure preservation of all neighboring buildings during excavation. For this particular operation, the project owner urged paying special attention to vibratory aspects (protection of buildings as well as their occupants and activities) and noise-related aspects (protection of neighbors), thereby making it necessary to establish warning and emergency shutdown thresholds.

The critical threshold for noise has been set at 5 dB(A) above a reference background level derived during regular daytime periods over several zones.

Orange limit

As for vibrations, an "orange" limit based on the ISO standard (i.e. a perception threshold of 0.1 mm/sec measured in 1/3 octaves (RMS) with a multiplier of 4 along the vertical axis) was introduced in the aim of mitigating nuisances for neighbors. A "red" limit serves to protect the built structures, through invoking the rules applicable to mechanical vibration emissions for landmarked facilities, i.e.: frequencies of between 4 and 8 Hz = 4 mm/sec; frequencies between 8 and 3 Hz = 6 mm/sec; and frequencies between 30 and 100 Hz = 9 mm/sec.

Driving supporting piles



Section view aligned with the abutting buildings on the avenue de la Bourdonnais

This 7-month project involved 3 to 4 cable-driven bucket excavation assemblies, 1 sludge mixing plant, 2 tooling stations for sludge-based pile-driving and 1 continuously-operating auger, all being run over a 13-hour workday. On average, a crew of 45 (reaching 75 during peak periods), including management and skilled operators, participated in this project.

Including execution

This building operation has provided the opportunity not only to raise awareness among project actors as regards environmental protection problems, but also to highlight the difficulties involved in terms of both noise and vibration, application of appropriate thresholds, position of measurement stations and implementation on a work site. It has also enabled making great strides towards incorporating environmental considerations during the execution phase of a major project.

SPECIAL REPORT

HEAVY LIFTING

Power to the point

More than 30 years ago, VSL came up with the visionary idea to use a combination of proven components from its strand post-tensioning system along with hydraulic jacks and pumps for lifting heavy loads. As an initial application in Sardinia, three 490-ton concrete dome shells for a series of circular aluminum silos were lifted a height of 28 m. Lifting and stressing of the steel cable net system for the acrylic tent-shaped roofs at Munich's Olympic Stadium in 1971 served as another milestone in this new erection technique. Strong growth in the market for alternative

Da Chi Bridge Pylon Lifting, TAIWAN

Working at height - VSL Taiwan was selected for this job in order to reduce the tremendous crane costs, hazards to personnel working high above ground for an estimated 150 days and concerns over on-site welding workmanship, project quality, windy site conditions and construction accuracy. The company's mission consisted of the design, supply and operations of a heavy lifting system to erect this steel pylon (1,280 t) quickly, accurately and safely.

A temporary stay tower behind the pylon provided anchor for both the lifting cables and backstay cables. The whole operation required just three working days.

Contact: jchang@vsl-tw.com

Palexpo Congress and Exhibition Hall 6, SWITZERLAND

Record roof lift - To save costs and improve quality, the 5,300-ton structure (20,000 m²) was assembled and then lifted on ground by 24 VSL strand units mounted on 4 temporary support towers. The main lift (12-m), took place in mid-February 2002. Following the installation of 4 column systems, the lifting cables were released, thus transferring roof load to the permanent supports.

Contact: ftrenkler@vsl-schweiz.ch

Bhairab Bridge, Bangladesh, INDIA

Innovative construction method - For deep submersion of some pile caps for the Bhairab Bridge project, pile caps with a dry weight of 3,300 tons were cast on a suspended above-water platform around 6 steel piles. For each pile, 2 VSL strand units provided concentric pile loading. After removal of the casting platform and an initial 9-m lowering, 6 casing tubes were placed around the piles and then sealed to the pile cap. Together with "donut" seals at the pile cap soffit, these tubes allowed for dry concreting in order to seal the steel piles into the concrete cap, after lowering a further 7m fo final level.

Contact: dtrayner@vsl-sg.com

Afsin Elbistan B Power Plant, TURKEY

All-round services - VSL was contracted to provide strand jack-lifting services for erecting boiler suspension grillages (530 tons), together with less bulky items like flue gas ducts and an impressive number of other heavy components. VSL services started up in autumn 2001 and will extend

through mid-2003. On-site hydraulic lifting equipment includes around 70 strand units with capacities ranging between 100 and 3,300 kN. Upon completion of this contract, the total weight of components lifted by VSL will have reached 10,000 tonnes.

Contact: psiegfried@vsl-schweiz.ch

Maureen Alpha platform, NORWAY

Innovative deconstruction method - The Maureen Alpha Platform is presently being deconstructed in a Norwegian fjord. As an initial step, the 10,000-ton Hi-Deck, was separated from its floating substructure, transported to the shore and then jacked onto shore for subsequent

dismantling. This 85-m sliding operation was carried out in mid-May 2002 using the VSL strand-jacking technique. VSL will be involved in the lifting and lowering work for deconstruction of the 3 steel tanks and connecting support structures.

Contact: ftrenkler@vsl-schweiz.ch

heavy lifting (lifting by means other than cranes) reveals that the strand-lifting technique has more than ever become state-of-the-art and that VSL continues to be a major player in this market. Both the equipment and its controls have been improved and new fields of application opened up for this technique. VSL's Heavy Lifting system has contributed to enhancing quality, compressing construction schedules and saving costs. VSL continues to stand for innovative engineering, high safety standards and reliable performance.

Tucuman Power station-ARGENTINA

Accurate to within 10 mm - For the lifting of two boilers (850 tons each) at a height of 18 m, VSL used a synchronized lifting system between the jacks. The maximum allowable difference between two points needed to be less than 10 mm after each stroke.

Contact: vslargen@correo.com.ar

Airbus Assembly Hall - FRANCE

Aéroconstellation-Airbus, Toulouse - As part of the "Aéroconstellation-Airbus" project in Toulouse, VSL-FRANCE was called on to perform the roof-lifting job (4,500 t, 120 m x 250 m) for a hangar using 28 lifting points spread among

16 poles. Following two partial operations conducted in October and November 2002, final lifting of the entire structure will take place in January 2003.

Contact: jean-claude.peslier@vsl-intrafor.com

Deepwater sewage system, SINGAPORE

Handling a tunnel boring machine -

In February 2001, VSL lowered a 420-ton tunnel boring machine (TBM). VSL's services included design and supply of a heavy-duty sliding track system and a gantry equipped with strand units to lift the TBM, slide it over the shaft opening, lower it by 40 m and ultimately rotate it by 16° for

alignment with the tunnel axis, before placing it on a launching cradle.

Contact: dtrayner@vsl-sg.com

Aquitaine Bridge, FRANCE

Four-point suspension -

For modifications to the suspension cable anchorages of the Aquitaine Bridge over the Garonne River, the anchorage modification imposed on the left abutment a new concrete structure measuring 10 x 4 x 30 m and weighing 3,500 tons. The main contractor needed to cast this anchorage at a lower level and then lift it through 30 m to reach its final position. After a first liftoff stage over 30 mm, the main lift with full load was carried out in March 2002 by VSL France using 12 SLU-330 strand units, arranged so as to provide 4-point hydraulic suspension of the load.

Contact: jean-claude.peslier@vsl-intrafor.com

Power production plant, AZERBAÏJAN

Moves of heavy machinery -

For placing a gas turbine and generator, VSL began by lifting 12 heat-recovery boiler modules weighing a total of 1,700 tons. Subsequently, the MHI gas turbine along with an ABB generator, each weighing some 350 tons, were lifted off their transport vehicles outside the machine hall, moved into the building and then placed onto their foundations by means of VSL's steel gantry and strand-lifting units. Site work was carried out during October and November 2001.

Contact: rruprecht@vsl-schweiz.ch

Lanjarón Viaduct - SPAIN

An innovative solution for a single-span bridge -

The structure to be launched consisted of a bowstring formed by two parallel trusses, with a single span of 114 m and a weight of 504 tons. It had to span a 90-m deep valley without any intermediate support. CTT Stronghold (VSL Spain) first loaded the structure with a counterweight and moved it using two VSL SLU-70 units. From this advanced position, the cables for the second phase were installed from the extremity of the bridge to the towers and concrete structures installed on the other side of the valley. The bridge was then pulled across.

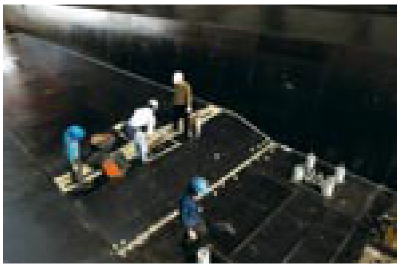
Contact: jmartinez@vslsp.com

THSR PROJECT IN TAIWAN

Full span pre-casting for high speed erection

When the Taiwan High Speed Rail Project was conceived, the question was how to build a 340 km Rail Link of primarily Viaduct, interspersed with Tunnels, in a hurry. An unusual alternative option, that of "full span pre-casting" (FSPC) was mooted for the C215 works in Taiwan.

Whereas in-situ options such as cast-in-place and pre-cast segmental structures, are well known in Taiwan, with multiple standard and advanced shoring systems common throughout the island, FSPC has been rarely used. In fact, there are only a handful of equivalent structures throughout the world as structures of this size have, in recent years, tendered to be pre-cast segmental. A technique such as FSPC promised the structural advantages of a single monolithic box girder for the double track (13m wide) plus a speed of erection faster than one bridge span per day.



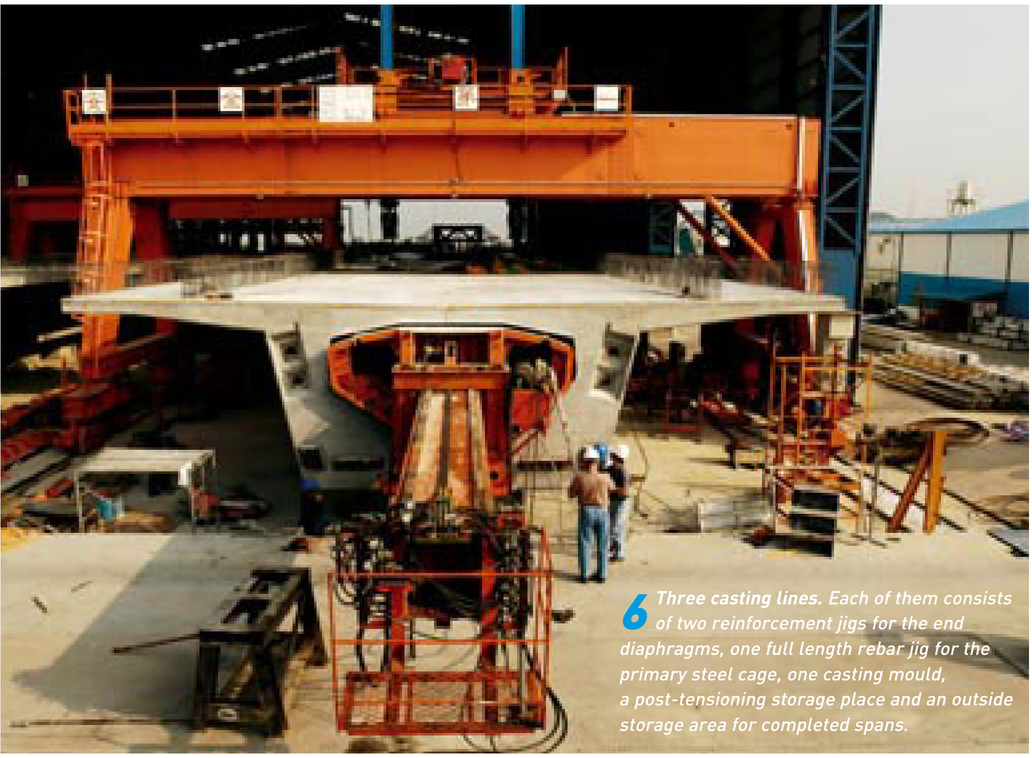
2 ***Preparation of the mould.*** *Formwork (square frame with a few transverse bars) for a permanent access opening in the bottom slab of the formwork.*

Over 600 pre-casted spans

The Taiwan High Speed Rail corridor runs on the western side of Taiwan from Taipei in the north to Kaohsiung in the south. The track has a 350 km/hr design speed and maximum operating speed of 300 km/hr. For civil works, tenders were initially called in late 1998 with the subsequent award of 12 no. major packages in early 2000. Successful tenderers were generally joint ventures of major local and international contractors. In the north, the first two sections (contracts C210 and C215) were awarded to a joint venture of Obayashi and Fu Tsu with the potential of some 20km of FSPC contained within the C215 contract.

5 ***Truss launching beam.*** *This 40m long beam is supporting the 30m long inner formwork. On both sides of the beam can be seen the bottom part of the inner formwork. In the foreground, steel bulkhead and coupling strands.*

3 ***Cleaning of external and bottom formwork.*** *Formoil is applied already. In the front left and right side, connected to the bottom form panel is a recess plate with 4 corrugated steel ducts which will form a recess for the dowels of the bridge bearing. On the left side, rebar concrete spacers have already been placed on top of the bearing recess plate and some spacers are now going to be place on the right side.*



6 ***Three casting lines.*** *Each of them consists of two reinforcement jigs for the end diaphragms, one full length rebar jig for the primary steel cage, one casting mould, a post-tensioning storage place and an outside storage area for completed spans.*

Subsequent to this, Obayashi- Fu Tsu JV let a major sub-contract, encompassing all pre-casting and erection of some 602 no FSPC bridge spans, as well as 7 in-situ free cantilever bridges to a joint venture of specialist European contractors VSL and Rizzani de Eccher. Work commenced on site in 2001 with the first pre-casting achieved in June 2002 and the first span's erection one month later.

2 days per 30m-beam

Both the design of the spans and design of the casting yard have centred around a target peak cycle of 2 days per 30m beam per casting bed. The pre-cast yard is mostly covered by a purpose built factory and consists of three casting lines, each with the ability to operate independently. The cycle is such that the diaphragm

4 ***Coupling strands.*** *Bulkheads and pre-tensioning strands are installed and will be prepared for stressing. For a 30m box girder there are 98nos. of 0.6'' pre-tensioned strands and 88nos of 0.6'' post-tensioned strands.*

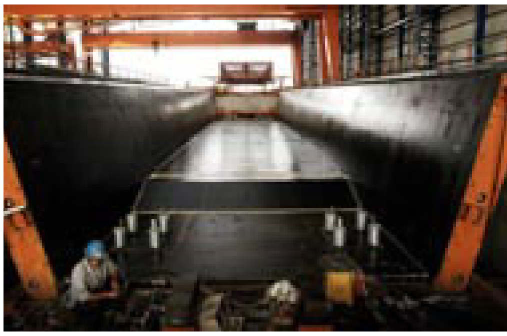
1 ***Fabrication of rebar cage.*** *The diaphragm rebar cage is prefabricated inside a diaphragm jig. During lifting in, the team has to make sure that the rebar is located properly.*

rebar cages are lifted into the primary reinforcement jig where the main cage, weighing in excess of 50 tonnes, is completed. Bulkheads and pre-tensioning strands are installed and stressed and the concrete is poured. The addition of steam curing and release of the pre-tension jacks completes the 2 day casting cycle for the 740 tonne, 30m long box girders. The transport and erection of such huge box girders, up to 20kms from the point of casting, is pivotal to the success of the FSPC method. VSL and its partner have adopted an approach where the device for transport forms an integral part of the device for the launching of the box girders. The system contains one "carrier" and one "support beam" (see pictures).

The carrier is an overhead beam supported by two rotating 8 tyred trailers over a 45m span which moves crab-like over the stored box girders, lifts them and transports them. The support beam is a 72m-long steel box girder which rests on the completed span at the rear and on steel legs and carries a service trolley on its top chord.

Drive–in erection

On arrival at the new span's erection location, the carrier drives into the support beam with the front trailer straddling the beam and its service trolley. Jacks on the service trolley raise the front of the carrier and the assembly of carrier and box girder is pulled out onto



7 ***Strand preparation.*** *Cleaning of the strand coupler attached to the coupling strands. After cleaning the strands, the rebar cage will be lifted into the mould and the couplers connected to the strands in the cage.*

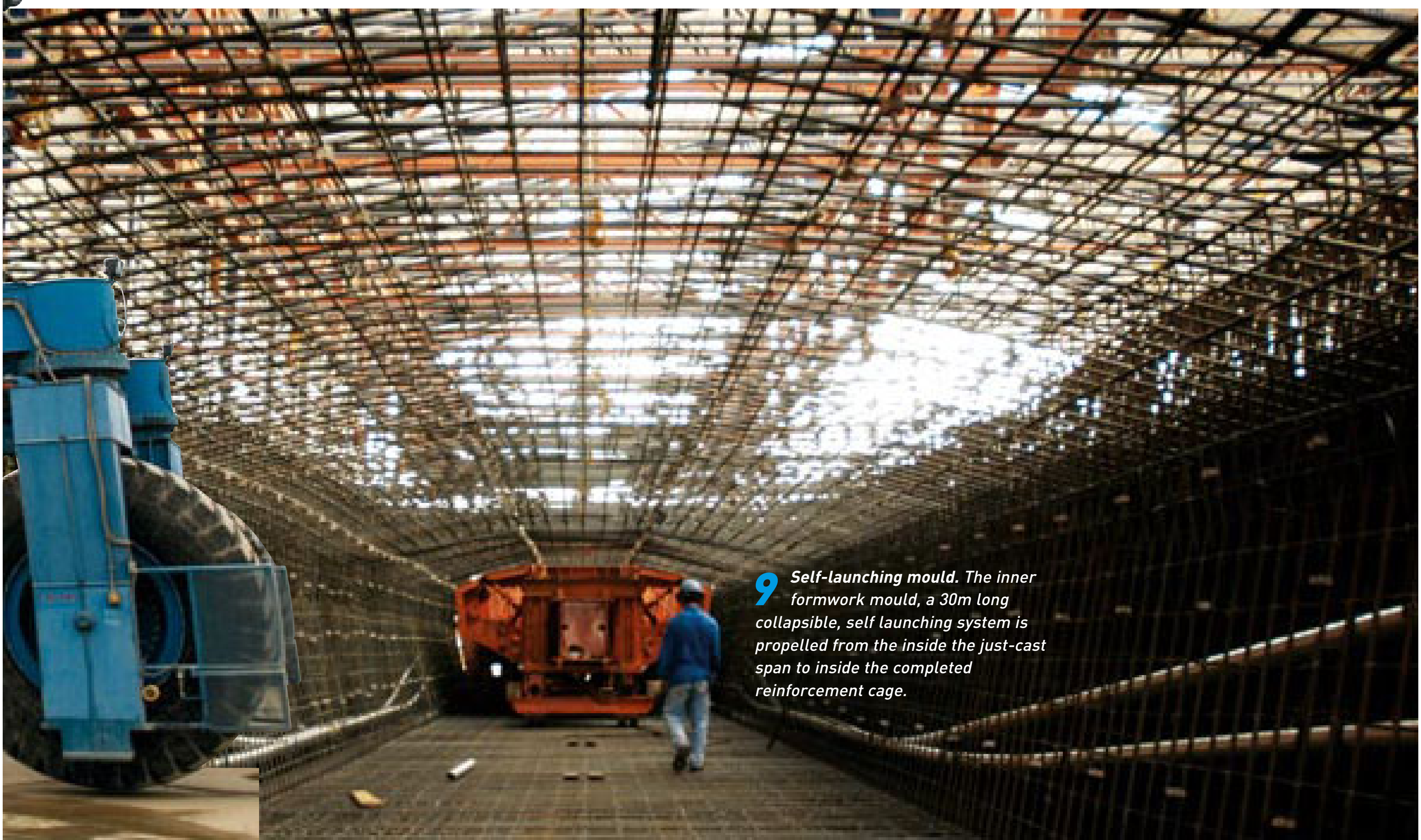
8 ***Pre-tensioning work.*** *Coupling strands for the pre-tensioning work are going through the steel stressing bulkhead. Inner formwork (upper part right) is launched towards the mould.*

13 ***Crab-like transport.*** *The carrier is an overhead beam supported by two rotating 8 tyred trailers over a 44m span. It moves crab-like over the stored box girders in the casting yard, lifts the unit to be erected and reverses from the casting yard where the trailers are rotated 90°.*

12 ***Long distance travelling.*** *The girders travel up to 20 kms from the point of casting.*

10 ***Storage.*** *The heavy lifting gantry transfers the box girder to the storage yard.*

11 ***Huge beams.*** *Each of the 602 box girders weigh up to 740 tonnes!*



9 ***Self-launching mould.*** *The inner formwork mould, a 30m long collapsible, self launching system is propelled from the inside the just-cast span to inside the completed reinforcement cage.*

16 ***The support beam.*** *This 72m-long steel box girder is launched into each new erection position such that it rests on the pier with the fixed rear leg and on the following 2 piers with its mobile supports. On its top chord, the service trolley traverses the full length of the beam.*

the support beam. At the stage where the box girder is suspended above its final position, the support beam is launched from underneath so that the box girder can be placed. The support beam is retracted slightly, the carrier reversed onto the newly place deck and returns for the next cycle.

With the commissioning period underway in July and August, and allowing for subsequent learning periods, full production was achieved in late 2002 with works carrying on through 2003 and completed in 2004. ■

14 ***Delivery at 4km/hr.*** *The carrier travels to the support beam, at a loaded speed of 4km/hr, along the previously erected viaduct. The transport and erection of such huge box girders, up to 20kms from the point of casting, is pivotal to the success of the FSPC method.*

15 ***Follow up works on the piers.*** *Pot bearings are grouted and the load is then transferred from the temporary jacks to the pot bearings.*

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