VSL NEWS

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DESIGN

Graceful silhouette

BALUARTE BRIDGE, MEXICO

Don't look down!

SPECIAL ISSUE: INNOVATION

highlights

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PROMOUVOIR LA GESTION DURABLE DE LA FORÊT

IMPRIM'VERT

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Cover photo: Margaret Hunt Hill Bridge, USA

EDITORIAL

Leadership in innovation

VSL's success is founded on the ability of its people to think outside the box to provide optimum solutions for clients and partners in all circumstances.

Innovation is a core element of these solutions: the capacity to take a step back, to question if there is another way - a better way - of working. This is our driving force.

Innovation comes when new business lines are created that stay in constant touch with the ever-changing market and focus on clients' needs in increasingly important sectors, such as nuclear power, offshore structures and infrastructure protection.

Innovation also applies to products, by constantly improving existing ones or creating even better ones. New or improved products strengthen VSL's lead in post-tensioning technologies, increase quality and productivity, and open up new paths for designers when creating imaginative structures. VSL's SSI 2000 Saddle and the new VSlab anchorage are shining examples of our engineering strength and innovation.

Innovation is also at the heart of our relationship with the client and this means a lot to us: efficient partnering allows us to take on more responsibility and to share more risk on important infrastructure projects, for the benefit of all parties. This issue of our VSL News Magazine presents some of these innovative ideas, tools, products and solutions. We strive to introduce them every one of our clients' projects. We want to make sure that we provide what's best for the project.

Daniel Rigout, Chairman and CEO

VSL ACADEMY

Triple certification

The VSL Academy in Bangkok passed its latest milestone in June when it achieved triple certification in ISO 9001 (Quality Management Systems), ISO 14001 (Environmental Management Systems) and OHSAS 18001 (Health & Safety Management Systems).

Independent accreditation body SGS Thailand carried out the initial assessment at the Academy, which has now been in operation for more than three and a half years. As part of the audit of the Academy's management systems, the assessors observed the training activities, verified the training documentation and looked at the management processes used to drive continual improvement. In its certification report, SGS highlighted that the VSL Academy had demonstrated that it provides a structured framework together with the systems for the management of training. The assessors commented on the high qualifications of the trainers, who all have a good knowledge of VSL technologies, and concluded that the Academy had also demonstrated the implementation and effectiveness of the training provision process.

For several years, it has been VSL policy that all parts of the Group should seek and achieve QSE (Quality-Safety-Environment) triple certification to the three internationally recognised standards. Many individual subsidiaries were already certified to ISO 9001 and they were the first to extend their QSE management systems to include the environmental and health & safety (H&S) elements.

The VSL Academy team decided to set up an integrated system from

the start and seek certification to the three standards simultaneously to reduce duplication and to speed up the process.

More time and effort was needed initially to design, develop and put into place the framework but this was soon outweighed by the benefits:

- There was an integrated system right from the start, with no need for any later changes to incorporate environmental and H&S elements.
- The integrated approach helps to cultivate a culture where environmental and H&S elements are incorporated into everyday thinking and ways of working.
- Internal audits look at all three QSE elements at the same time.
- In the same way, integrated management reviews now include all QSE aspects.

Working under these management systems defines a framework that provides a real focus on the essentials, an effective risk approach and better operational controls for Academy activities.

In addition, the changes in approach provide a safer and more environmentally friendly working environment for trainees. The Academy has become a centre of excellence for VSL core activities, with quality, environmental and health & safety issues incorporated into classes and training areas. Regular feedback and reviews from attendees lead to continual improvement.

On a practical level, the standards of learning are verified through site visits and audits. Senior Academy staff members have all been trained as internal auditors and carry out regular site audits across VSL. The Academy contributes to improving VSL's operations by trialling and testing new ideas, products and equipment and by acting as a hub to receive operational feedback (both good and bad) as well as communicating best practices (and those to be avoided).

Whilst certification represents the end of a development phase, it is also the beginning of a consolidation and improvement phase. It is essential that the high standards achieved are maintained and that the management system drives constant improvements in the effectiveness of our services and how we deliver them. Everyone involved can be proud of their achievements, which we are sure will be the springboard for further developments and improvements. ■

PT IN BUILDING

Green way takes the lead

Malaysia's first LEED gold-certified building has been built using an alternative design that was proposed by VSL. The Shell SSC building in Cyberjaya was developed under the EMKAY Group banner and was completed at the end of 2010. Almost 80% of the 61,000m² 'green' building incorporates the VSL post-tensioning system, with approximately 230t installed. The building houses five levels of office space and three sub-basement levels of parking. It is designed to save energy and natural resources and provide for a healthier and safer environment. Construction of the entire structure took just six months. ■

COMMUNITY ACTION

Engineers for the day

A dozen school students in Dallas became engineers for the day when they toured the Santiago Calatrava-designed Margaret Hunt Hill Bridge project and built a scale model. The students were enthusiastic about what they had learnt from the tour. ■

HEALTH & SAFETY

New management tools

VSL has passed the Australian government's accreditation process for occupational health and safety (OHS). Maintaining accreditation requires stringent reporting and monitoring and so new tools have been added to the VSL Australia Information Management System. The system captures and records OHS activities as well as tracking actions. As a result, personnel are now more proactive in implementing OHS. Centralising information has improved efficiency and QSE (Quality, Safety, Environment) teams spend less time managing data. ■

HEALTH AND SAFETY

Drive carefully

VSL has issued a new vehicle use and safety policy which applies to all VSL activities around the world. Road traffic accidents are one of the biggest risks that many of us face while at work (or getting to/from work), yet we rarely think about them and we often overlook them during risk assessment exercises. The aim of this instruction is to promote good practices as a means to reduce the risks and to reduce the number of road accidents suffered by VSL employees and/or partners. This instruction defines the minimum safety requirements for VSL personnel using vehicles on the road. ■

SPONSORSHIP

VSL on top of the world

The VSL logo has been displayed on the top of the world as part of an expedition to climb Mount Everest. VSL Switzerland sponsored a member of the team supported by specialist construction company Gasser Felstechnik. ■

COMMUNITY ACTION

Continued support

VSL has continued to support the Long Hai Community Center in Vietnam through various initiatives.. The donation of VSL's nine boxes of gifts was welcomed and received by the centre's vice-director Mrs Huyen and pupils. The VSL team was pleased to see that construction of the centre's extension is making good progress. ■

Cable-stayed bridges
Rapid cycles

→ **VSL China achieved a rapid six-day cycle** for the complete installation of each set of twin deck segments on the Wuhan 27 Bridge over the Yangtze River in Wuhan City, China. The contract was awarded in October 2010 for the supply and installation of 3,600t of the VSL SSI 2000 Stay Cable System, using 264 cables up to 336.2m long. The bridge has three 215m-high pylons supporting two main spans of 616m and side spans of 250m, for a total length of 1,732m. The investment for the structure was made by the Wuhan Municipal Development Corporation while the design was completed by China Rail Major Bridge Design Institute. Stay installation was completed in September 2011. ■ *Contact: hao.guan@vsl.com*

Stay cables
Korean first

→ **South Korea's first three-way cable system** is currently being installed on the Mokpo Grand Bridge, which has a 500m main span. Main span cables are anchored at the outer rails while side spans cables terminate within the median strip. VSL's scope includes supply and installation of 1,345t of stay cables, as well as pylon construction and precast segment erection for the 4,129m-long bridge. The main contractor for the project is GS E&C. ■ *Contact: whkang@vslkorea.co.kr*

New territory
Intrafor's ground improvement in the ME

→ **Intrafor has entered the ground improvement market in the Middle East.** Successful trials of equipment from Dutch manufacturer ICE led to an order for four vibroflots. Commissioning in June was followed immediately by the award of Intrafor's first contract to use the equipment. The project is for stone columns at a sports facility in the royal palace grounds in Abu Dhabi. ■ *Contact: jeanchristophe.gillard@vsl-intrafor.com*

Repair
Carbon fibre upgrade

→ **VSL, working with Sika Australia,** has started its latest bridge repair and strengthening project. The works on the Ginninderra Drive project in Canberra require installation of 152 carbon fibre strips in combination with 43 VSL Stressbars. In addition, VSL will lift the bridge deck to allow the contractor, Abergeldie, to replace the bearings. The bridges are part of the 9km upgrade of an arterial road connecting northern Canberra to the Tuggeranong Parkway in central Canberra. ■ *Contact: felix.blumschein@vsl.com*

Bearings
New Polish venture

→ **VSL has won its first bearings contract in Poland.** The bearings are for the E-118 bridge on the A4 Tarnów-Dębica highway and the contract follows post-tensioning work already awarded by SIAC/Hydrobudowa. CTT Stronghold (VSL in Spain) manufactures the 150 pot bearings, in sizes up to 1,483mm by 1,383mm and weighing up to 2,364kg. They are installed by Bouygues subsidiary Karmar. ■ *Contact: m.targowski@vsl.com.pl*

Load testing
From 0 – 1,000t in 10 seconds

→ **VSL Heavy Lifting has installed equipment** to simulate storm loadings on a full-scale offshore wind turbine mock-up in Cuxhaven, Germany. Loads of 1,000t have to be achieved within just 10 seconds during the 1,200,000-cycle testing of the influence of wind and waves on gravity foundations. VSL's solution uses two SLU 580 units and pumps delivering 520 litres of oil per minute. A web-based application gives live remote control of the system. ■ *Contact: rino.kaufmann@vsl.com*

Atomexpo 2011
Networking goes nuclear

→ **VSL has exhibited for the first time at the annual Atomexpo international forum.** Atomexpo 2011 in Moscow brought together top executives and specialists from world-leading companies working in the nuclear industry. Exhibiting enabled VSL to showcase its services as an efficient partner for post-tensioning and monitoring for the construction of nuclear reactor buildings. ■ *Contact: sebastien.elias@vsl.com*

Ground engineering
Deepest shaft

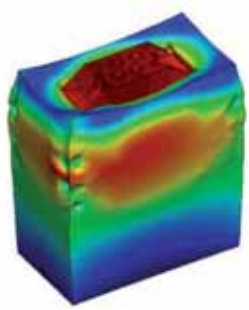
→ **Intrafor has completed its deepest ever shaft, finishing four months ahead of schedule.** The 91m shaft is part of Hong Kong's Harbour Area Treatment Scheme. Intrafor developed patented sacrificial void formers for the project. Achieved tolerances on verticality were extremely low, well within requirements, and the jointing between the panels was made with high quality, thus providing very high water tightness, and avoiding the need for expensive and time consuming concrete finishing or trimming. ■ *Contact: henrypc.chan@vsl-intrafor.com*

Stay cables
Building Bellavista

→ **VSL and SEC Peru have completed their work** on the iconic Bellavista Bridge Peru's first stay cable bridge. The symmetrical bridge for the San Martin Regional Government has two identical 56m-tall A-shaped pylons, supporting two 65m side spans and the 190m main span. VSL supplied and installed 128 VSL SSI 2000 stays, as well as assisting the client and designer in the project's early stages and helping the main contractor with geometry control. ■ *Contact: jluna@vslsp.com*

Focus on innovation

Innovation has always been at the heart of VSL's activities. The continuous search for renewal and change - without necessarily abandoning well-established and proven products - is a core pursuit of the group. Be it a new product developed by the R&D department or an innovation created locally and suitable for implementation around the world, the VSL network is constantly driving improvements. The desire not to stand still, but to look



ahead, to think outside the box - that is the recurring theme. Within VSL, innovation stands for the creation of better and more effective products, technologies and processes, or the improvement of existing ones - with the constant objective of better serving its clients. The following pages give a – non-exhaustive – introduction to some of the most interesting innovations of the last few years.

LIFTING FRAMES AND TRAVELLERS – LATEST INNOVATIONS

Developments in the support of deck segments in cantilever construction

Purpose

Innovations in lifting frames and travellers help ensure that the bridge deck can be erected smoothly and safely while taking account of the requirements and restrictions encountered on site.

Description

Every project that uses form-travellers or lifting frames has its own specific requirements, such as the need for unrestricted overhead access, minimised self-weight or limitations on segment lifting locations.

Some of VSL's innovations are useful on multiple projects, such as the modular system for travellers developed by VSL-TCAA.

Others are for specific projects, such as a new type of overhead traveller designed by VSL-TCAA for the Gateway Upgrade Project in Brisbane, Australia. It gives unrestricted overhead access to the segment area and allows prefabrication of the web reinforcement.

Innovative lifting frames have been developed for projects including the Industrial Ring Road in Bangkok and Stonecutters Bridge in Hong Kong. In Bangkok, the main loading is taken by direct strut/tie action based on a simple triangle design. This simplifies installation and keeps the weight within limits.

For the Seremban Viaduct in Malaysia, the lifting frame can not only lift segments at the tip of the cantilever but can also pick up segments at the opposite cantilever end and transport them to the erection front.

Both the Shenzen Western Corridor (SWC) and Airport Link Brisbane have twin decks that were erected by the free cantilever method using a pair of cantilever frames sitting on both decks. The upper cross beam (UCB) is equipped with an SLU or a winch for handling segments for both decks.

Advantages

- Smooth and safe deck erection taking into account each project's requirements.
- Maximisation of the opportunities for reuse of the equipment elsewhere due to the use of a modular system

NEW

VSoL® PANEL ART

Creating murals using VSoL panels

Purpose

Creation of patterns in the front face of panels produces a continuous mural effect when the panels are erected side by side to form a wall.

Description

A number of issues have arisen when creating mural-style artworks in walls using conforming foam formers. The foam leaves a different texture on the front face of the panels. It is not of a uniform thickness and so the depth of the raised relief varies from one panel to the next. The foam is difficult to mask with silicone because it is a soft material, which also means that it is easily marked by vibrators and normal construction activities. All of these issues meant that reworking would be required.

The foam pieces have been replaced with rubber, which presented challenges when cutting due to the higher strength of the rubber. This was solved by using water jet cutting, which cuts the rubber easily and leaves a finish suitable for casting against without the need for any rework. It also reduces the need for silicone. The rubber material has also proved suitable for use on the curved front face of panels, where rigid materials cannot be used.

Advantages

- Advantages over the foam material : reduced requirement for rework and a better overall finish.
- Improved production due to reduced need to use silicone around the individual pieces.
- Key advantage of the rubber over rigid materials: enough pliability to mould to the correct shape on the table mould. Otherwise, the individual pieces cut cannot be lined up and have to be treated later by sanding back.

EXPLORING THE LIMITS OF THE VSL SADDLE

Testing the VSL SSI Saddle with smallest radii

Machine for small radius saddle testing, installed in the laboratory of the technical university of Berlin

Stay cable bridge (UAE)

Catumbela cable-stayed bridge (Angola)

Purpose

The VSL SSI Saddle has established an enviable reputation, because of its performance and also its ease and speed of installation. The saddle's injected inverted tear-drop hole, which supports a single strand, has become an icon of innovation in bridge construction.
Two full-scale fatigue tests had already demonstrated the saddle's outstanding performance. A further testing programme has now been carried out to explore the limits of the saddle.

Description

The VSL SSI Saddle system design combines high fatigue durability and high differential force transfer. The saddle's operation is based on the use of individual strands that deviate in injected inverted tear-drop holes.
The aim of the latest testing was to find out the smallest radius of the saddle whose performance still satisfies fib requirements, as well as pushing further to find the extreme limits of the system.
The rig for full-scale saddle testing was designed in a joint development between VSL and the technical university of Berlin. It had to be sufficiently robust to withstand fatigue loading corresponding to two million cycles with a stress variation of 200MPa and a maximum tension of 45% of the cable's guaranteed ultimate tensile strength (GUTS). The loading included a 0.6° static deviation of the stay cable combined with the dynamic deviation induced by the tension variation.

Advantages

- A robust and efficient saddle opens the way for the construction of new structures that are more slender, more ambitious, easier to build, more economic, more… futuristic.
- Exhaustive information on system performance will be determined by testing and published to enable new designs to take advantage of the saddle.

ADDITIONAL COLOURS FOR SSI 2000 STAY PIPES

A choice of stay pipe colours to suit individual structures

Purpose

VSL has assisted its clients for many years in building cable-stayed bridges and other structures around the world and today these structures stand out as true landmarks. They pay tribute to the science as well as the art of structural engineering, by combining slenderness and efficient engineering with an aesthetically pleasing arrangement of the cables. For a long time, the focus has been on structural performance and durability, but their visual appearance is becoming ever more important. This includes the colour of the stays.

Description

The increased emphasis on visual appearance has led VSL to extend its SSI 2000 stay range with additional standard colours for high-density polyethylene (HDPE) stay pipes. VSL now offers seven standard colours, allowing owners and designers to select what best suits their structures. Colours range from bright red and yellow through varied shades of grey to blue and white.

In addition to the new standard colours, VSL can address special requirements for other colours upon request. In such cases, a new colour batch can be designed, and tested to validate its compliances to VSL's specifications. A lead time of about 9 months will however be required to allow application of the equivalent durability testing regime.

Even the brightest colours have been developed to meet the strictest durability requirements and VSL has carried out extensive testing to validate each of the seven proprietary colour mix designs. They have been tested in independent laboratories, covering such varied aspects as mechanical and chemical resistance as well as ageing. Particular focus has been put on long-term behaviour through accelerated weathering tests under laboratory conditions and real-time climatic exposure around the globe.

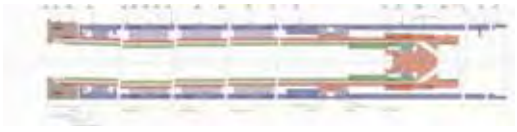
Advantages

- Wider choice by bringing colour to VSL SSI 2000 stay pipes while staying true to its principles of only supplying the most durable systems to the market
- Full control of the entire production process from mix design through raw material selection to pipe production and testing by VSL, with the strictest quality control criteria applied in accordance with the latest international standards and guidelines

NEW

DIRECTIONAL CORING USING A STEERABLE BARREL

Continuous rock coring along a curved alignment



Purpose

The use of a steerable core barrel enables continuous coring that follows a predetermined alignment (such as the one for a proposed tunnel) to ensure accurate assessment of the ground conditions.

Description

The aim was to develop a system for more accurate detection of faults, large seepage zones or other features so that risks and project costs could be better evaluated. In particular, Intrafor wanted to enable continuous rock coring along a sub-horizontal curved alignment for ground investigations on projects such as tunnels and mines.

The cores are retrieved using Intrafor's directional barrel, which enables a curved route to be steered to obtain the core. This is achieved by aligning the drill rod using multiple deviation bearings. A diamond coring bit is used with a swivel arrangement so that drill rod (red) can turn while the core-catcher (green) and outer casing (blue) remain stationary. A 3D borehole survey probe is used to check the borehole alignment.

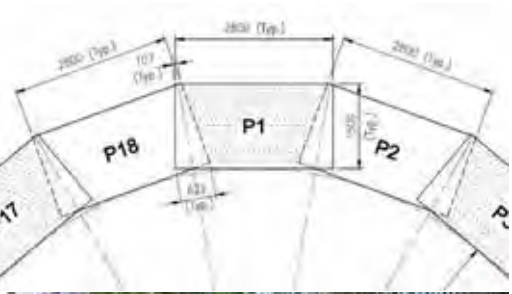
Advantages

- Information about rock quality is collected continuously along the borehole's route. The cores can be tested for mechanical chemical properties including strength and abrasion along the whole of the alignment, giving a better assessment of costs and production rates as well as reducing risks. This is particularly important for projects such as major tunneling works, especially when using a tunnel boring machine.
- Use of the steerable directional coring technique reduces the number of holes, which minimises the environmental impact and the number of permits required.
- Flexibility in terms of access points, as the ability to steer enables the hole to be started in the most suitable location.
- Holes may be used to install instrumentation, such as settlement sensors, along the tunnel alignment.

NEW

SOFT MILLED JOINT FOR CURVED DIAPHRAGM WALLS

Ensuring faster closure of wall panels while maintaining vertical control



Purpose

The aim was to enable faster excavation of the closing panels between panels that had already been cast, while maintaining the good vertical control that is essential for shafts.

Description

When excavating the closing panels in a diaphragm wall with angles, a lot of hard concrete has to be milled from the primary panels because of the large overlap on the inner side. This can mean a large volume of wasted concrete, high consumption of cutter teeth and damage to the cutting wheels and gear boxes. There can also be difficulties in maintaining vertical control, bringing the risk of non-matching panels at depth. This is a critical issue for circular shafts. The solution is to insert softer 'void formers' at the locations to be milled. First, concrete spacers are installed on the rebar cage. Then the 'soft joint' elements - in this case made of lightweight concrete - are attached to the cage between the spacers.

Advantages

- The scheme avoids the increased costs, production times and risk of panel misalignment.

NEW

MATCH-CAST SEGMENTAL BRIDGE PIERS

Fabrication of bridge piers in offsite precast factory facilities

Placement of a crosshead unit on match-cast pier columns

Precast crosshead segments

Two match-cast pier moulds in operation

Match-cast pier segments in storage

Match-cast pier mould in operation

Purpose

Precasting is adopted to avoid the issues encountered when casting bridge piers on site, where work is often carried out close to live railways or roads subject to weather conditions and under tight programme constraints.

Description

VSL is currently pre-fabricating bridge piers using match-casting techniques in off-site precast factory facilities. The method involves dividing the pier into units (segments) that are easily handled with standard equipment. Generally the ideal size for a segment is a height of between 1.5m and 2m, combined with a weight of between 15t and 30t. However, larger segments of more than 100t can be produced.

The sequence starts by casting a base segment in a mould, corresponding to the base of the pier. A '+1' segment is then match-cast in a mould on top of the base segment. Both segments are then removed from the moulds and the +1 segment is placed where the base unit previously stood. A '+2' segment is then match-cast on top of the +1 segment and so on, with the process repeating until the complete pier is cast.

Segments are delivered to site and can be stacked very quickly into position by crane on the cast-in-situ pile cap. They are stressed down to create a pier that looks and behaves exactly as a conventional pier.

Advantages

- Precast fabrication allows piers to be erected in a fraction of the time taken by in-situ casting – an entire pier can sometimes be erected in a single shift
- Important programme gains
- Minimises lane closures and rail shutdowns
- Quality advantages when elements are cast in factory conditions, isolated from adverse weather and within better established manufacturing and control systems

NEW

PRECAST CONCRETE TANKS

Savings using precast concrete instead of steel for liquid-retaining structures

A completed structure at Tarago Water Plant in Victoria, Australia

Purpose

The aim is to construct a traditional water-retaining structure using precast concrete elements as an alternative to steel in order to produce more economical and programme-efficient tanks.

Description

Traditionally, steel had been used to construct water tanks throughout Victoria, Australia. The cost of construction was considerable and progress was dependent on the weather. Steel tanks require skilled labour to carry out the delicate on-site welding work.

Precasting panels off site allows them all to be prepared in advance, ready for delivery and erection. Panels are delivered to site on completion of the base slab and erected at a rate of approximately 12 to 15 panels per day. Erection takes about six to 10 days, depending on the size of the tank.

Horizontal post-tensioning tendons are installed. The joints are then cast with concrete. Once the wet joints reach sufficient strength, the horizontal post-tensioning is carried out to make the structure watertight. Traditional water stops and compressible membranes are used at the interfaces between the precast panels and the base slabs. Roof erection work takes place once the panels have all been stressed.

Advantages

- Precasting helps keeping programmes under control, thanks to the offsite production and under-cover casting conditions
- Smaller crews with lower skill-sets required for the work
- Reduced schedule possible for site erection works - including the base slab and roof construction
- Post-tensioning provides an active and positive means of maintaining a watertight structure

NEW

FULLY AUTOMATED TANDEM MOTIVE UNIT (TMU)

The linear winch: continuous movement of large loads in inclined shafts

Hydraulic circuitry with 12 valves added to a standard heavy lifting pump unit.

The heart of the control desk with a programmable logic controller (PLC)

TMU during installation

Purpose

The boom in wind power means that the demand for pumped-storage hydropower plants has risen dramatically. As a consequence, there is a growing demand to move heavy tunnelling equipment in inclined shafts, which can be more than 1km in length. Winches are normally used but reach their limits when the loads exceed 20t and the distances are very long.

Description

Strand jacking using Strand Lifting Units (SLUs) or Strand Motive Units (SMUs) is perfect for standard heavy lifting tasks but the limited stroke length of the jacks means that movement is intermittent. Lowering operations even require a reversal of the direction for a short distance during each piston cycle.

To provide a continuous movement, two jacking units have been placed in series on the same strand bundle to form a Tandem Motive Unit (TMU). While one piston moves the load, the other returns to its start position. This is a complex process, especially for lowering, and would be impossible to handle manually. Hydraulic circuitry and an automated control system have been developed so that the operator has just three buttons - up, down and stop.

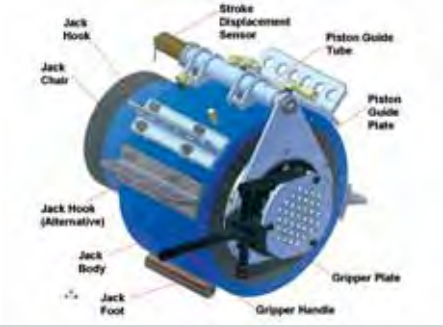
Advantages

- Allows continuous movement at high speed and an almost unlimited strand length, with a small size, weight and power requirement.
- Simple to operate and provides a high degree of redundancy as there are several individually anchored strands instead of a single winch cable.
- The TMUs that have been developed have a capacity of up to 144t each at a speed of 40m/h. They have already been proved in operation on a scheme in Spain and tenders are being submitted for further projects.

NEW

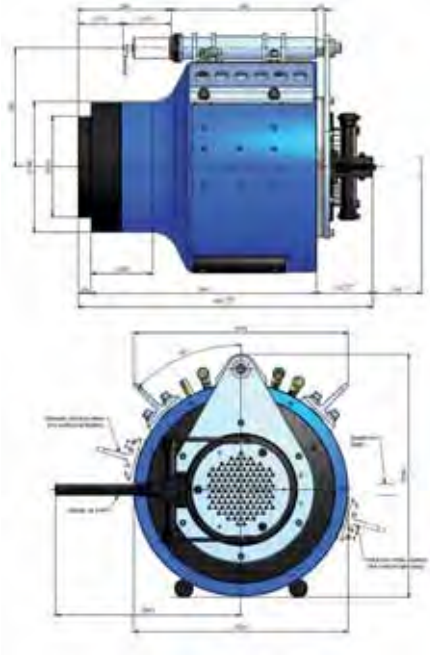
NEW MULTI-STRAND STRESSING JACK FOR POST-TENSIONING

Preparing for future high-capacity strands



Isometric view from the rear of the stressing jack.

Mid-range size stressing jack ZPE980, capacity: 980tons at 600bar, designed to stress up to 31 numbers of 0.6" strands



Purpose

The development of the new jack had to meet a challenging set of objectives. It was designed to accommodate new future strand capacities with a minimum breaking load of 310kN, while also achieving a lighter and more compact design for easier handling and use in smaller anchorage recesses. Other objectives were to improve safety and handling during stressing operations and to create a standardised design across the range.

Description

The detailed design specification was finalised following a thorough survey carried out worldwide in 2007. This formed the basis for the new range of jacks, together with new standardised pumps. Design by TCAA's equipment team was completed last year. All of the new design specifications have been met and several new jacks were ordered and fabricated earlier this year. The first completed product was a mid-range ZPE980 stressing jack, which has a capacity of 580t at 600bar and is designed to stress up to 22 strands of 0.6".

Advantages

- Lighter and more compact jacks for easier handling
- New safety feature: the handle that operates the gripper plate can be installed either on the right or left side, which eliminates the risk of the operator standing directly behind the jack during stressing operations.
- The tapered front end of the jack allows stressing to take place in more confined anchorage recesses.

VIBRATION CONTROL SYSTEM WITH HIGH-DAMPING RUBBER

Mitigating wind- and seismic-induced vibrations and deformations in building structures

Purpose

Building structures are prone to vibration and deformation when subjected to wind and seismic forces. Normally, the status quo is restored once the force ceases. However, permanent deformation of the building will result if the deformation exceeds the elastic deformation range, affecting the structure's strength and stability. The installation of a VSL Damper system can increase the damping ratio of a structure. It also improves the structural safety capacity and the comfort of users.

Description

Using an energy dissipation system with devices to absorb the vibration energy reduces the stress on the structure's components as well as the deformation and the degree of shaking. Research findings have identified the effectiveness of the different damping systems available. Tuned mass dampers or active mass dampers should be used for high-rise structures subject to strong wind effects. Base isolation systems could perform better in a large scale earthquake, however, but their application is limited to low-rise structures and good ground conditions.

VSL's viscoelastic dampers are suitable for a wider range of building structures; they play a role irrespective of the size of the earthquake and or wind loading. By absorbing and dissipating seismic energy while yielding, they immediately reduce the amount of structural deformation as well as the structural vibration and the displacement response, thus giving an excellent control of the structure behaviour. The structure's safety is therefore improved. That allows tuning the damper reaction to best fit its response required against the vibrations. VSL's viscoelastic dampers can be made as brace-style, wall-type and slab-type models. They comply with the building's structural designs and functional requirements.

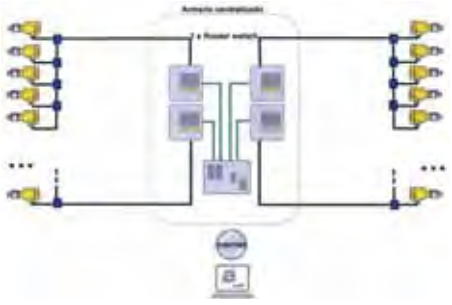
Advantages

- Enhance the seismic performance of the structure and increase their service life, without requiring a power supply
- Space saving, easy to install, maintenance free and long service life
- Increasing the damping ratio reduces the structural response under wind- and/or earthquake-induced vibrations. This has an impact on base shear, displacements and acceleration, and improves the comfort of occupants
- Versatile system to suit different design requirements.

NEW

INSTRUMENTATION OF BEARINGS

Monitoring of loads for spherical and pot bearings



Purpose

An instrumented bearing measures the actual vertical loads that are acting upon it. The purpose of the instrumentation is to detect any changes and deviations in the load distributions on the structure. Instrumentation enables the changes to be detected immediately, so that the effects on the structural members can be determined.

Description

Instrumentation has been developed for both spherical and pot bearings. It works on the principle that the structure's vertical loads are transformed into pressure on an elastomeric pad. This pad is confined in the bearing and when the load is applied it can be considered as a hydrostatic element; as a consequence the pressure is constant in the entire element. The pressure on the elastomeric pad is measured by a sensor with a membrane connected to strain gauges. The sensor is incorporated into the bearing, with the membrane in contact with the elastomer. Once the load is transmitted from the structure to the bearing, the pressure deforms the membrane and it changes the electrical resistance of the sensor. These changes allow the system to use the variances in electric potential to calculate changes of loads.
A choice of methods is available to capture the data. Information can be captured directly from the bearing by using a wired connection. Alternatively, central data storage can be set up on the structure to capture information by a wired connection or by wireless methods.

Advantages

- Instrumentation of VSL bearings is an effective way of adding value to the product
- Relieves customers from the need to measure deflections or strains on their structures.

PRECAST PILES AND COLUMNS FOR A MAJOR BRIDGE

A precast solution to minimise temporary works for marine piles

Setting a precast shell over the piles

A precast shell, ready for setting steel reinforcement

Erection with barge crane

Precast column elements were match-cast horizontally

Purpose

A 1,300m long bridge is being built across a sea channel to connect Abu Dhabi to one of its islands. The VSL-AST joint venture is the main contractor for the entire bridge construction and associated works. VSL's partner, AST, is specialised in foundation and marine works and was in charge of the substructure.

The management of the JV worked with AST and VSL management after the contract award to review and evaluate all of the engineering solutions with the aim of improving the schedule and resource use. VSL's experience led it to suggest that precast pile caps and columns should be considered.

Description

VSL, together with the designer, developed the design and methods related to the use of the precast elements. All elements have been precast on site and handled directly by gantry crane or barge crane. Column precast elements are set in place, with stress bars positioned between each pair of elements. Final permanent post-tensioning is then applied from the pier head down to the pile caps.

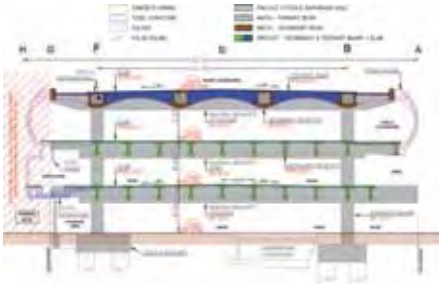
Advantages

- Use of precast shells for piles caps enables fast production rates and reduces the amount of temporary works and formwork needed in the sea around the pile
- Use of precast columns avoids problematic logistics during the concreting stages
- Eliminates the need to handle formwork in marine conditions
- Enables a fast pace of work and provides a safer environment
- Higher quality finished product.

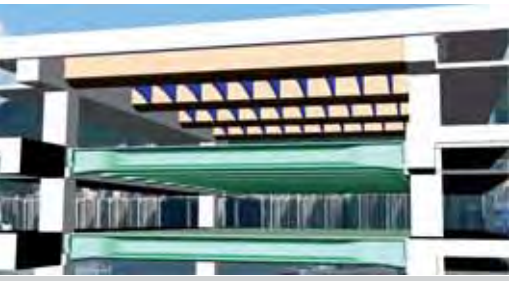
NEW

USE OF PRECAST AND BRIDGE TECHNOLOGY TO CONSTRUCT LARGE SPANS IN A BUILDING

Innovative design on the Cruise Terminal Building in Hong Kong



Typical section of the three-level building across the secondary beams



Geometry and post-tensioning layout of a precast secondary beam

Lifting precast secondary beam out of formwork

Purpose

Maximising the amount of precast construction in the Cruise Terminal Building was identified as a way of reducing construction time, providing a better quality product and reducing the amount of labour on site.

Description

The main Cruise Terminal Building is a three-level structure on a footprint of 610m by 66m. The project features very long spans: 45m in the primary direction and 34m in the secondary. VSL developed several framing schemes for Dragages HK to maximise the use of precast construction. The concept uses simply supported secondary beams for the 1st and 2nd floors, with a continuous flexible 'link slab', as is commonly used in bridge construction.

The primary beams typically span 45m between columns and cantilever up to 12m at each end. For the 1st and 2nd floors, these primary beams have a box section and a continuous corbel on either side to support the precast secondary beams spaced at 5.6m. These precast post-tensioned secondary beams are 31.5m long and 2.3m to 2.5m deep. They are designed as simply supported on elastomeric bearings with a continuous, flexible 'link slab' connected to the box beam. The 'water drop' shape of the secondary beams had been jointly developed with lead architect Foster + Partners.

For the roof floor, which follows a wave-shaped profile, the secondary beams are made continuous with the primary box beams. They support vaulted precast tertiary beams, which in turn support the precast slab.

Advantages

- Use of techniques from bridge construction enabled a design where a substantial part of the framing could be precast, without having to introduce more movement joints than a continuous structure.
- Ability to cater for unconventional beam shapes
- Provide a faster handover and add more scope for the use of VSL's specialist skills.

NEW

EXTERNAL PT FOR PRESERVATION

Using post-tensioning to bring a historic chimney back into use

The historic chimney now stands in a new development.

An intermediate ring was fitted.

General view during strengthening

The first-stage stressing operation used a low-capacity jack.

Purpose

A 44m-high brick chimney of historic interest has been given a new lease of life using external post-tensioning.

Description

A brick chimney built in 1872 has been reinforced by vertical external post-tensioning on its inside and monitoring has been installed. The 44m-high chimney was part of a textile complex and has now been put back into use to serve adjacent buildings. Strong reinforcement was needed to meet the change of use, coupled with the latest wind and earthquake requirements. The solution chosen after detailed analysis was external post-tensioning that could be retensioned or replaced, if necessary.

The location near adjacent buildings meant that the new reinforcement had to be very reliable as tendon failure could destabilise the structure, causing collapse.

Key features of the chosen post-tensioning solution include:

- using external tendons inside the chimney allows more space for installing the outlets for pipes
- they behave as unbonded tendons
- they can be restressed, are easily replaceable and are visible for inspection

Use of a restressable system enables compensation for any losses such as those arising from masonry creep under the new loads. Bonding to the structure uses structural adhesives to avoid damaging the bricks.

Space limitations led to the incorporation of an indirect tensioning system. In the first stage, tendons were tensioned using light jacks. Further tensioning could then be added by “pressing down” using an intermediate ring and high-strength bars.

Each of the five tendons has been instrumented and alarms warn if the prestressing force drops below 80% of initial values.

Advantages

- The strengthening has been backed by a comprehensive monitoring system to give assurance of the structure’s stability.
- Monitoring is possible by timed data recording which captures readings every hour and the results can be viewed or downloaded from a secure web site.

REPLACING BEARINGS WITHOUT DISRUPTING TRAFFIC

New technologies allow structures to remain open during bearing replacement

Purpose

Bridge bearing replacement is a task that generally interferes with the normal use of the structure, causing traffic disruption. Today's agreements between operators and local authorities or governments often impose penalties and sanctions when traffic is adversely affected by the maintenance work. The amounts of these penalties can far exceed the costs of the operation and so it is increasingly important to find ways of keeping the traffic flowing smoothly.

Description

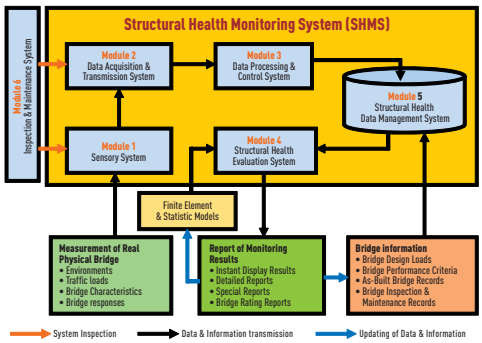
New technologies are available to carry out the replacement operations for pot and elastomeric while allowing normal use of the structure. These operations require very detailed engineering and the use of systems that are highly reliable. Techniques include load transfers that minimise the vertical displacement by keeping it to less than 2mm while also keeping to horizontal constraints. Operations are synchronised and monitored in terms of pressure and displacement. Other techniques include specially developed hydrodemolition methods and the use of ultra-fast-setting grouts that achieve a strength of 25MPa in just two hours.

Advantages

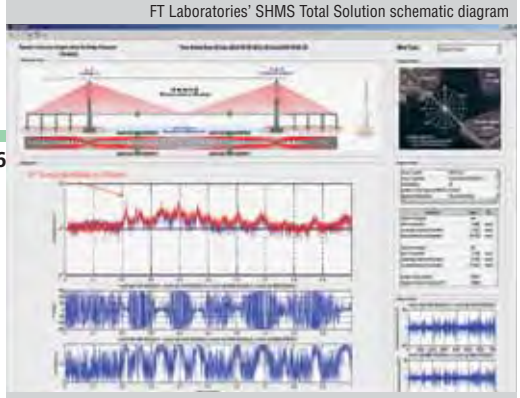
- Avoiding traffic disruption meets client's requirements and user's requests

SHMS TOTAL MONITORING SOLUTION

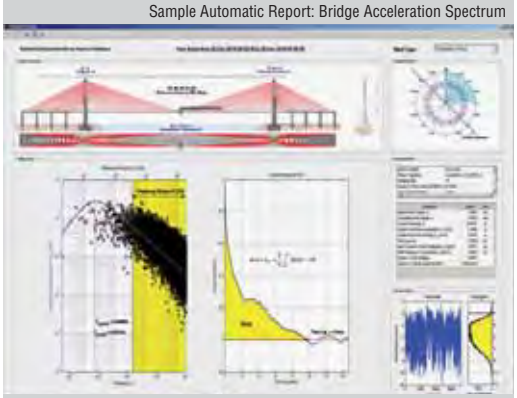
FT Laboratories' total solution for structural health monitoring



FT Laboratories' SHMS Total Solution schematic diagram



Sample Automatic Report: Bridge Acceleration Spectrum



Sample Automatic Report: Wind Acceleration Spectrum

Purpose

FT Laboratories' Structural Health Monitoring System (SHMS) Total Solution provides a comprehensive approach for data collection, presentation, processing, evaluation, rating and reporting. It starts by monitoring the loading and structural parameters using real-time data sensors. The information can be used to evaluate the bridge's structural performance and to plan a comprehensive structural inspection programme. It can also be used to determine the cause of any damage, as well as the extent of any remedial work required.

Description

The FT Total Solution goes further than the traditional system, which encountered difficulties in processing because of the massive data volumes involved.

The Total Solution extends data interpretation through integration with the latest information and structural analysis technologies. It overcomes the limitations of a file-based system by introducing an additional module - Structural Health Data Management System. This module enables better control and eliminates redundancy by integrating data and information files for efficient retrieval and easy maintenance.

There is automatic input of measured and processed data such as the wind spectrum, accelerations, GPS displacements and dynamic strain data. Automated plotting of 3D time-series data is used to determine the deformation pattern of the structure under loadings. Automatic synchronised processing can be carried out for different types of correlation analysis and pattern recognition.

Advantages

- Complete solution for today's monitoring requirements
- Online monitoring of environmental loads
- Structural responses and correlation of the results to the structural design criteria
- Structural health results can be used to predict the structural responses to facilitate the planning of inspections and maintenance.

FT Laboratories Ltd.

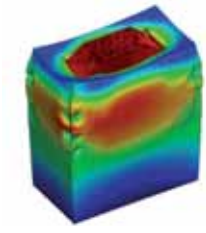
NEW

ANCHORAGES: VSLAB® S-SERIES

A new system for slender slabs

Resistance to static load:
a 6-5 anchorage with measuring equipment during static testing

Resistance to fatigue loading (2 million load cycles)



Load transfer to the structure
During the development stage, the local zone reinforcement was optimised with numeric FE modelling and by experimental testing.

Purpose

VSLAB® S-Series has been developed to allow 0.6 inch (15.2mm) strand technology to be used in even the thinnest slabs.

Description

The new VSLAB® S-Series is based on 0.6 inch (15.2mm) strand technology with a flat duct for use in slender slab elements. The S-Series has been detailed to maximise efficiency and minimise friction losses. The block-out size is designed to be integrated in the thinnest slabs and still allows early stressing for accelerated construction cycles. The 'slap-on' principle (installation of the anchorage after casting of the concrete) offers major advantages to contractors by separating the critical paths of concreting and post-tensioning installation. Grout caps are available as an optional accessory, further enhancing the durability of the system by providing maximum protection against aggressive environmental agents.
It has been tested for static loads, fatigue loading to two million cycles and to optimise the load transfer to the structure.
The VSLAB® S-Series will become the latest member of VSL's anchorage family to comply with Technical Approval Guideline ETAG 013, offering an appealing new alternative in the slab market.

Advantages

- VSL's 0.6 inch system is a highly efficient alternative to the existing 0.5 inch (12.7mm) systems still in use in some areas, extending its range of slab anchorage units to all intermediate tendon sizes up to five strands. A 6-2 is equivalent to a 5-3 tendon size.
- The new VSLAB® S-Series can be used in combination with flat steel ducts or with VSL's proprietary PT-Plus® plastic ducts, which provide reduced friction during stressing and enhanced corrosion protection.

Tendon size	Tendon capacity (140mm² /1860 N/mm²)	Tendon capacity (150mm² /1860 N/mm²)	Weight of anchorage body
6-2	520 kN	558 kN	2.5 kg
6-3	780 kN	837 kN	3.4 kg
6-4	1040 kN	1116 kN	5.0 kg
6-5	1300 kN	1395 kN	6.5 kg

NEW

Vietnam

Saigon tower

→ **VSL has successfully completed the installation of 590t of strand** for the Saigon M&C Tower in Ho Chi Minh City. The building includes a 23,000m² commercial centre and a 34-storey, 49,000m² office development. VSL devised the post-tensioned slab and beam design for main contractor Bouygues Bâtiment International (BBI). BBI's use of a top-down method meant that VSL could work independently on both, upper and basement floors, achieving cycles of six to seven days per level while meeting strict quality requirements. ■ *Contact: lan.tranduc@vsl.com*

Australia

Wall developments

→ **VSL has designed and supplied 13,000m² of VSoL® wall panels** for the Mandurah Entrance Road. The walls allowed the new road to be built with grade separation close to an existing rail line. Meeting tight delivery requirements meant casting an average of 50 panels a day.
The project featured two design developments of the VSoL® system, involving the use of fibreboard for sandy backfills and a new temporary support design. ■ *Contact: thomas.haydon@vsl.com*

Australia

Jacking the boxes

→ **VSL has completed what is believed to be the single largest jacking operation** ever undertaken in the world. It was one of the most complex elements of Brisbane's Airport Link project. The operation used VSL Heavy Lifting strand jacks and push jacks to push two concrete boxes into position under a railway. The larger of the boxes was 21.4m wide, 12.5m high and 65m long. Its design jacking force of 26,000t required 28 strand jacks and 14 push jacks. ■ *Contact: david.trayner@vsl.com*

Australia

Formwork innovations

→ **VSL has been using an innovative new formwork system** as part of its work with the Hunter Expressway Alliance on construction of the expressway's eastern section. The work involves building three viaduct bridges totalling 840m, 40m above ground over mine subsidence areas. This requires precasting of columns and bridge segments, erection and post-tensioning of columns and installation of permanent bearings.

A new innovative formwork system for precast concrete columns has been used together with a 165m-long launching gantry to erect the 75m spans. The Hunter Expressway Alliance has subcontracted VSL Australia to design and supply approximately 12,360m² of VSoL®. On another section of the Hunter Expressway, Abigroup have engaged VSL Australia to design and supply over 12,000m² of VSoL®.

■ *Contact: jonathan.davies@vsl.com*

Korea

Gateway pylon

→ **The 100m-high asymmetric curved concrete pylon** of the 2nd Geumgang Cable Stayed Bridge is designed to resemble a gate for Sejong City. VSL Korea was appointed for a full package of work covering pylon construction and the supply and installation of precast panels, stay cables and post-tensioning for the pylon and deck. The 200m main span has a composite deck of steel grillage and concrete panels with in-situ stitches.

■ *Contact: whkang@vslkorea.co.kr*

Brunei

Police inspections

→ **VSL has completed its work as specialist subcontractor** for the structural appraisal and repairs of a police station built on concrete stilts in Brunei Darussalam's famous 'water village'. The project team carried out a thorough investigation of the deteriorated beams, slab and columns through visual inspection, non-destructive tests and testing of extracted samples before executing the repairs. A year had been allowed but the team finished in just nine months, despite harsh conditions. ■

Contact: whkang@vslkorea.co.kr

NOTE PAD

Express installation. *The Entasis-Intrafor Consortium is building 1.5m-thick diaphragm walls to depths of 55m for the West Kowloon Terminus approach tunnel (south) as part of Hong Kong's Express Rail Link. There are approximately 100 wall panels, with a total concrete volume of almost 25,000m³. Work also includes the installation of shear pins, fissure grouting and the removal of an existing breakwater.*

Export link. *Work continues on Indonesia's Pedamaran cable-stayed bridges, where VSL is providing the stay cables combined with its saddle system. The two bridges will become an important link in the exporting of palm oil from Indonesia to Malaysia. Both bridges have a similar 460m length, made up of five spans with four 32m-high H-shaped pylons.*

Night-time window. *VSL has completed the precasting of 27 beams for the So Kwun Tan Bridge. Erection will take place within tight night-time windows early in 2012. Each of the bridge's three spans is made up of nine prefabricated 20m-long I-beams, each weighing 33t and stressed with VSL 5-31 and 5-19 tendons.*

Freeway panels. *VSL has been engaged to design and supply VSoL® retained earth structures for the 27km Peninsula Link freeway in Australia. Work involves wall design, precasting, panel delivery and component supply. Innovative aspects of this project include a two-stage design for walls up to 10m high and a three-coloured, three-textured finish on hexagonal panels.*

Indonesia

Triple technology

→ **All three contract packages on the 3.5km elevated Jalan Layang Non Toll road** are being built using VSL technology. VSL is involved in the post-tensioning and erection of precast box girders for the Casablanca, Satrio and Mas Mansyur contracts. In particular, VSL Indonesia has supplied and operated a launching gantry for Casablanca and two pairs of form-travellers for Mas Mansyur. Typical spans are 50m but a Mas Mansyur section has a 111m span. Its pier table will be built with precast segments and followed by cast-in-situ balanced cantilever construction using form-travellers.

■ *Contact: tmijarsa@vslin.com*

Taiwan

Crossing the Keelung River

→ **Upon completion, this 180m long cable-stayed bridge,** the Shi-Zi Bridge, will be a new landmark over the Keelung River and will link the traffic from Taipei city to the She-Zi Island. The bridge pylon raises 105m above the deck level of the bridge and is inclined at an angle of 78°.

In cross-section, the shape and dimensions of the legs change continuously. The side span installation involved cable sizes of 6-121 up to 97m long while the main span's 6-73 cables have a maximum length of 171m. ■

Contact: jack.tsai@vsl.com

Hong Kong

High-speed wall

→ **Intrafor has taken just four months** to build a 1.2m-thick diaphragm wall with a total volume 24,000m^3 and a depth reaching 60m below sea level. The design and construct project was for the basement of a new residential development in Tseung Kwan O for leading property developer Sung Hung Kai. Intrafor mobilised a hydraulic cutter, three grabs and four cranes in order to meet the tight schedule, achieving an average production rate of 1,300m^3 per week.

■ *Contact: yw.yung@vsl-intrafor.com*

Hong Kong

Avoiding disturbance

→ **Construction of a two-storey basement in Sheung Shui** brought considerable challenges as the adjacent three-storey buildings stood on shallow friction concrete piles and pad footings. Intrafor's main contract for designing and building the basement included construction of a diaphragm wall, subsequent excavation and provision of lateral supports, installation of 3m-diameter cast-in-situ concrete bored piles and pile cap construction. Intrafor's careful choice of methods and equipment avoided any disturbance or settlement of the surrounding buildings. ■ *Contact: alan.liu@vsl-intrafor.com*

Malaysia

PT on 2nd Penang

→ **Two adjacent 17km viaducts are being built as part of the Second Penang Bridge project,** which will link Penang Island with the mainland. Each viaduct comprises a trapezoidal segmental box girder spanning typically 55m between piers. VSL, as part of a joint venture, was awarded a subcontract by UEMC for the supply and installation of 13,000t of post-tensioning as well as grouting supervision and technical assistance. Construction by the match-cast segmental span-by-span method uses four gantries to erect the 8,092 precast segments. ■ *Contact: cheeken.chong@vsl.com*

India

Crossing the mighty Ganges

→ **A record-breaking erection gantry is being used by VSL** for a new bridge over the River Ganges in the state of Bihar. The bridge has 125m spans and a total length of 5.5km. VSL's approach is to avoid working at river level and so it has designed, built and operates a 270m-long gantry – one of the world's longest gantries. VSL India was awarded the contract by Navayuga Engineering and is working with the VSL technical centres to complete the bridge three months ahead of the originally planned 33-month programme. VSL's work also includes all precasting and post-tensioning. ■ *Contact: saravanan.subramanian@vsl.com*

Hong Kong

A quality finish

→ **VSL is achieving a high level of concrete finish at the new Kai Tak Cruise Terminal Building.** Dragages Hong Kong awarded VSL several key elements including construction of the post-tensioned structures. The work involves more than 2,000t of post-tensioning as well as precasting and erection of 226 post-tensioned secondary beams. Foster + Partners designed the beams with a tear-drop shape which will be fully exposed, thus requiring a very high level of finish. ■ *Contact: jeanchristophe.gillard@vsl-intrafor.com*

UAE

Record-breaking link

→ **The two buildings of Abu Dhabi's Nation Tower Complex** are now linked at an altitude of 202.5m by the world's highest link bridge.
The complex consists of two buildings - a 65-storey residential tower and a 52-storey tower including a luxury hotel, offices and a retail podium. The two towers are connected at the 50th and 54th level by the skybridge structure. VSL raised the 385t bridge by 178m at a rate of 20m/h, despite a wind speed of approximately 35 km/h during the lift. A further challenge came from the asymmetric load distribution. Once at the final height, the bridge was slid laterally into its permanent position on its abutments. VSL's Heavy Lifting solutions allowed the complete assembly of the skybridge on the ground, and lifting the finished structure in place, thus speeding up construction times and increasing the quality while assuring the safety of staff at all times. ■

Contact: david.gratteau@vsl.com

Serbia

Bypass technology

→ **VSL technology is playing a key part on three bridges** on Serbia's Dimitrovgrad Bypass. VSL received an order to deliver anchorages, ducts, strands for the bridges and to provide equipment and supervision. The superstructures are made of prestressed concrete girders, designed with the VSL post-tensioning system. Almost all of the 216 girders are 34.4m long and 1.95m high, post-tensioned with four tendons 6-12. Delivery is due for completion in December 2011. The main contractor is Ogranak ALPINE Beograd. ■

Contact: wilhelm.brunnsteiner @vsl-germany.com

Germany

Incremental launch

→ **A new 280m-long deck is being launched over the existing piers** of the 60-year-old Sondern Bridge crossing Germany's Lake Bigge. Severe damage to the original concrete deck meant that replacement was the only solution. The deck is built in 50m-long sections behind one of the abutments and is then incrementally launched using VSL's strand jacks. Total weight for the completed 280 meters of bridge reaches 810t. ■ *Contact: robert.monger@vsl.com*

Romania

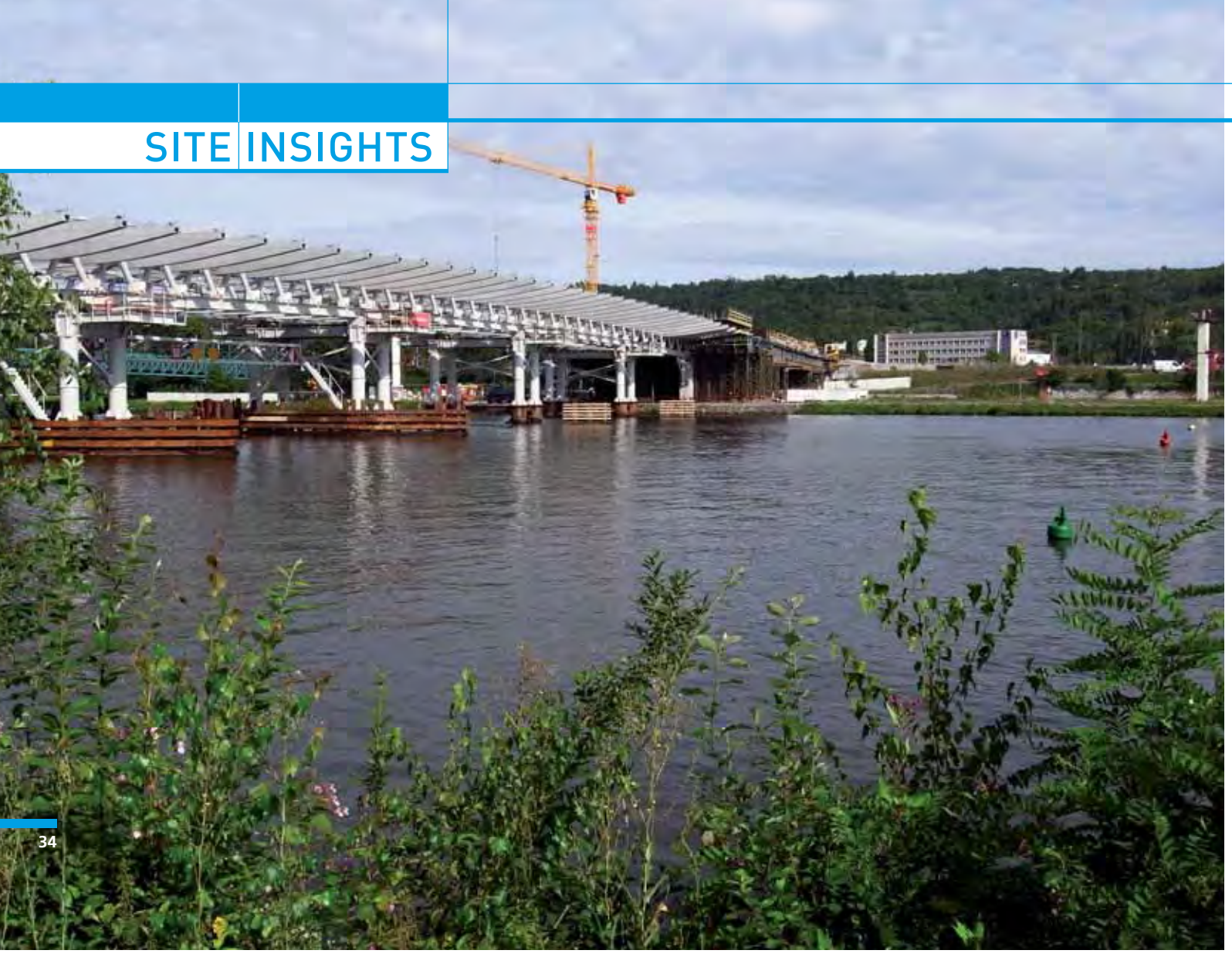
Delicate operation

→ **A highlight of Romania's new National Arena** is a retractable roof with a delicate cable membrane structure, which was lifted and tensioned by VSL Heavy Lifting. An unusual feature of the cable net lifting operation was that two radial layers were raised simultaneously from the compression ring. The stadium's triple layer roof has 40 radial cables per layer, two tension rings with flying masts and a 9,000m^2 double-layer inner roof. ■ *Contact: wolfgang.schroeppel@vsl.com*

France

Parisian VSoL®

→ **A 500m-long VSoL® wall forms** part of the enabling works by DTP Terrassement and Bouygues civil works for a residential development in Paris. A new street has to be created; this is very rare in the French capital. The work requires construction of a double retaining wall as the adjacent railway has cutting depths of up to 10m. DTP Terrassement's VSoL® unit will use its own retaining wall technique: fill is placed one layer at a time and reinforced by steel tie-rods. ■ *Contact: b.chanteperdrix@bouygues-construction.com*



Czech Republic

Electrically isolated tendons for Troya

→ **Prague's new Troya Bridge is being fitted with electrically isolated tendons (EIT)** because of the close proximity of tram lines and a transformer. VSL is installing the EIT, which has the advantage of avoiding any risk of stray currents causing electro-chemical corrosion of the steel. The bridge has two parts: a 40m-span concrete structure and the main 201m-span steel arch, which has a concrete deck. Both are longitudinally and transversally post-tensioned using EIT. ■ *Contact: psmisek@vsl.cz*

USA

Mine rescue

→ **A project at a coal mine in Gillette, Wyoming,** involves strengthening two 62m concrete storage silos joined by a common wall. VSL has wrapped the silos with 404 Z6-1 external tendons, in combination with 413 Hayes Posilock 0.6 internal tendons in the common wall. The two silos, which are used to store the coal the mine produces, were badly deteriorated and could only operate at 50% capacity. The repair will bring capacity back to 100%. ■ *Contact: jobrien@structural.net*

Switzerland

Sliding finish

→ **VSL has completed the second 625m overland transport** of a tunnel boring machine (TBM) in Biel at almost double the first operation's speed. Client Herrenknecht again opted to move the complete TBM using the innovative procedure that VSL had developed. In 115 cycles of 5.5m, the TBM was lifted by VSS-500 units, slid forward on skidshoes and set down. An overall speed of 12m/h was achieved despite the route's curves and slopes. ■ *Contact: wolfgang.schroeppel@vsl.com*

Switzerland

Test flight

→ **A helicopter placed the first of three test anchors** for a scheme to reinforce the Illsee Dam against earthquakes. The test anchors were installed in August to verify that the production anchors can be placed without any surprises. VSL will deliver 62 rock anchors in 2012, in sizes up to 6-27 with free lengths of 30m and a 10m bond length. ■ *Contact: hannes.muller@vsl.com*

USA

Water cooler

→ **Post-tensioning is helping reduce costs and increase durability** of an underground tank at Utah State University. Chilled water from the tank will feed the university's air conditioning, thus substantially reducing the requirement for electrical energy. The 9m-tall tank, which has an interior dimension of 34.5m, will have backfill on top and is designed to carry emergency vehicle loading. When complete, playing fields will be restored on top of the two million gallon thermal energy storage tank's roof. ■ *Contact: janderson@structural.net*

NOTE PAD

On the Olympic road. *VSL is providing its SSI 2000 Stay Cable System for a new cable-stayed bridge being built by SK MOST on the main route to the 2014 Olympic Winter Games in Sotchi, Russia. The 552m deck with a main span of 312m will be supported from two pylons by 56 stay cables equipped with compact friction dampers.*

Tunisian spans. *VSL is providing a range of services for a total of 30 spans that make up two rail viaducts in Tunis. The work for SOMATRA-GET involves the provision of technical assistance, post-tensioning materials and equipment, as well as the design and supply of specialized formwork and a launching girder.*

Missouri icon. *The new kcICON Bridge over the Missouri River in Kansas City, USA, features VSL technology including the SSI 2000 Stay Cable System, Gensui dampers, Resipoly corrosion protection and the AMS stressing system. The bridge has a 168m main span, with the superstructure supported by 40 stays radiating from a delta-shaped pylon.*

PT supply. *A total of 1,100t of strand is being supplied for part of the 1,195km East-West Highway spanning Algeria. A joint venture of Japan's Itochu, Kajima, Taisei, Hazama and Nishimatsu won the 395km eastern section contract.*

Vital link. *Immediate reconstruction was essential when a typhoon tore down Jia Xian Bridge in Taiwan in 2009. A new 304m-long three-span arch bridge has now replaced the vital link. VSL's scope of work was to supply and install 58 nos. SSI 6-19 cables as vertical hanger for the bridge, using galvanized strand according to BS5896; relaxation 2, grade 1770 with waxed and HDPE sheath.*

Portugal

Regua refurb

→ **The old bridge built over the River Douro in Regua in 1872** has been closed to traffic and is now being repaired for reopening as a pedestrian crossing. Contractor Casais subcontracted VSL Portugal to repair the bearings. The top of the stone piers were reinforced with high-strength bars to allow jacking of the steel arch and removal of the bearings for refurbishment to give the structure many more years of life. ■ *Contact: ralmeida@vslsistemas.pt*

Mexico

Triple travellers

→ **A bridge on the Xalapa Ring Road is the first in Mexico** where three pairs of form-travellers are working simultaneously. VSL was appointed to supply and supervise the installation of 415t of post-tensioning and the form-travellers for the Km 61+000 Viaduct. It is being built by Idinsa on behalf of the concessionaire, CAPEXA, made up by Isolux and Mota-Engil. VSL, through designer IBT, proposed changes including the adoption of the segmental balanced cantilever method for installation of the 470m bridge. ■ *Contact: prangel@vslmex.com.mx*

Spain

Tilting up and down

→ **The topography of a valley in southern Spain** meant that two different construction methods were required to erect the arches for a pair of viaducts. The two viaducts were needed for a deep valley that is crossed twice by a new highway in the Las Pedrizas region. One has a central arch of 120m while the other arch is 115m. The semi arches were lifted for one viaduct and lowered for the other. Those for the larger span were cast horizontally on falsework at ground level. After lifting the first section, the falsework was modified to cast the second at the same location. Lifting was carried out using strand lifting units mounted on a jacking platform at the pier. The other viaduct required the semi arches to be cast vertically alongside the pier using a jump form, before being lowered into position. ■ *Contact: jmmartinez@vslsp.com*

Turkey

Bridge premier

→ **Mega Yapi - VSL's licensee in Turkey -** was the main contractor for the Beylerderesi Bridge, which is now complete and was opened by Turkey's prime minister, Recep Tayyip Erdogan in January 2011. The bridge's 190m-long main span is the country's longest built using the free cantilever method and crosses a deep valley on slip-formed piers standing 60m high. The total amount of prestressing in the deck is 600t and Gc anchorages were used. ■

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Chile

First to finish

→ **VSL has made the closing pour for Huasco Bridge,** which has a 116m main span and is being built using the balanced cantilever method. MC Sacyr Chile subcontracted VSL to build the bridge, which is the first of its kind in Chile. VSL's work included supply and operation of four form-travellers and provision of post-tensioning. Implementation of a night shift and accelerated concrete curing reduced the segment cycle up to three days. ■

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Mexico

Structural collaboration

→ **VSL Corporation Mexico has collaborated** on the structural design of post-tensioned slabs for Arena Mexico, a major sports and entertainment venue that will host more than 130 events a year. VSL is building 154,000m² of post-tensioned slabs using an unbonded monostrand system. VSL's solution speeds slab construction and reduces costs by approximately 10%. Arena Mexico's owner is Grupo Avalanz. The contractor is Grupo Garza Ponce and the designers are Alonso y Asociados and KMD Architects. ■ *Contact: ceciliaalto@vslmex.com.mx*

NOTE PAD

Nuclear replacement. *CTT Stronghold (VSL Spain) has been appointed by Westinghouse for heavy lifting and handling operations to replace the reactor vessel head at the Vandellós nuclear power plant in Spain. Extensive equipment is required for the operations, which include removing the existing head before installing its replacement in the containment building.*

Highway walls. *VSL in Mexico has completed installation of 32,900m² of VSoL® walls for the 'Mexican External Circuit' – a major highway expansion being built by OHL Group in the North East of Mexico. VSL built walls up to 15m high to contain the embankments and approaches for seven bridges on the highway and four crossing it.*

Smooth launch. *VSL Portugal has completed the incremental launching of the steel structure of the 300m-long composite deck for a viaduct over the EN224. VSL succeeded with main contractor Alves Ribeiro to propose an alternative to change the construction method. VSL's jacks moved the structure across VSL pot bearings, which were free-sliding during the operation and before being fixed permanently.*

Pier transfer. *CTT Stronghold (VSL Spain) has completed the transfer of loads of a bridge's 1.1m-thick slab to 13 new piers inside a concrete underpass at Montornés del Vallés. The slab had first to be reinforced and new piers built to reduce its 17.6m original span to 8m. VSL then picked up the 3,000t slab on 13 hydraulic jacks within a 1.5 mm tolerance prior to load transfer it to the new piers.*

DESIGN

Graceful silhouette

The latest addition to the Dallas skyline in the US is the Margaret Hunt Hill Bridge, part of an urban development that includes flood control, recreation and economic development. Aesthetics are a key factor for the project.

The bridge, part of the Larger Trinity River Corridor Project, has two main spans each of 183m. They are supported by 58 stays connected to a 123m-tall steel arch that tapers from 4.7m to 3.6m in diameter. The deck has a concrete surface and is supported by steel, with the stay cables anchoring inside a steel central box girder.

The arrangement of the stays is atypical in two ways - they are stressed in the centre of the deck and the longest stays are lowest on the arch. Attention to aesthetics was paramount and was part of every decision affecting the project. Access at the arch pylon presented additional challenges because all evidence had to be hidden after installation.

The bridge contract was bid in 2006 and VSL was selected to supply and install the stay cables, as well as carry out other erection work. Placing the stays that create the elegant Calatrava design presented VSL with opportunities for innovation and to address the challenges.

Innovation played a key role from the early stages of this project. Work on site for VSL started in May 2010 when a 1,000t crawler crane began the process of setting the large sections of the arch into place. The arch was supported by temporary stays and by the box girder on falsework. The clean lines of the arch were made possible, in part, because of advances in the VSL SSI 2000 system. The system now permits the use of a floating tension ring contained within the expansion sleeve, rather than the larger, bulkier deviator installed inside an external guide pipe. In addition to improving the appearance of the arch, the innovation reduced pylon construction costs and shortened installation schedules.

With the arch erected, work to install the remaining basic steel elements continued until the end of June and welding was completed in February 2011. The bridge deck concrete was placed during March and April, which allowed VSL to mobilise to begin stay installation in mid-April.

From the beginning of the installation the goal was a cycle that involved installing a pair of stays every day – a feat that presented a steep learning curve. Nearly every day, two pipes were erected, all strands were stressed and tension rings installed so that the cycle could begin again the following day. Keeping to the schedule was challenging initially but, by splitting the crew and adjusting the start times, VSL consistently met the schedule and gained back most of the time spent on the learning curve.
As soon as the initial installation was complete, VSL proceeded simultaneously with second-stage stressing and the pylon finishing works. Removal of the falsework supporting the deck applied the final theoretical force to the stays. The AMS system was used for all stressing operations throughout the project. A redesign and upgrade of the AMS control system allowed the crew to install 58 stay cables in 30 working days – cutting VSL's contract schedule in half. In addition, the accuracy and reliability of the stressing using AMS ensured that all strands were stressed within tolerance the first time without any need to equalise or make other adjustments – a benefit for the overall project schedule.

A factor that made the installation such a success was the attention paid to the plan for exterior access at the arch pylon. The attention to aesthetics that played a part in every decision meant that VSL was limited to four small mounting holes for the access system. Most of these were 150mm in diameter and situated near the top of the arch, approximately 120m above the deck. This challenge was

The designer of the signature bridge is Santiago Calatrava. Calatrava is an internationally acclaimed and award-winning architect, artist and engineer. An AIA Gold Medal winner, he is considered among the elite architects, designers and engineers of his generation and his works have been erected around the world.

addressed by the use of adjustable platforms, similar to those used for washing skyscraper windows. They were rigged to provide access to the exterior of the arch for strand installation, installation of tension rings and the closing of the expansion sleeves. To maintain access to the work, the platforms had to be re-rigged continuously all the way to the top of the arch. There were many windy days during this portion of the work and so the "swing stages" were secured to the skin of the arch with mechanically activated magnets. These solutions worked well, helping the team complete the installation and stressing while leaving the arch in pristine condition.

Once the survey results from the stressing had been analysed, the deck finishing work proceeded while the final few adjustments were made to correct for the thickness of deck concrete. Completing the final adjustments allowed VSL personnel to inject Resipoly into the stay anchorages. This material, a modified urethane epoxy slurry, is used to create a leak-tight anchorage system. Its effectiveness has been proven, as VSL's SSI 2000 system has passed the stringent fib leak test multiple times using Resipoly as the filler material in the protection caps. The two-part slurry is mixed together using a particular method to avoid the introduction of air bubbles into the material. It is then injected into the anchorage using vacuum equipment attached to connection ports in the protection cap. Resipoly bonds well to steel, and the sealing system of VSL's anchorage allows the vacuum to pull the material into all of the open space inside the protection cap and around the individual strands. Once the injection has been completed, the material takes anywhere from a few days to a few weeks to polymerize, depending on the surrounding air temperature.

The Resipoly injection process went very well. Within the arch, it was completed in a couple of weeks, and it only took a few days at the deck level. The deviator installation had to take into account some guide pipe misalignment, but otherwise was completed without incident.

The owner has been pleased with VSL's quality of work, professionalism, scheduling and overall performance. The bridge is now substantially complete and is expected to open to traffic in the spring of 2012.

TECH SHOW

THE BALUARTE BRIDGE IN MEXICO

Don't look down!

VSL Mexico is part of the consortium that has been awarded the overall construction contract for the Baluarte Bridge and its approaches. The project, which is being carried out with three other Mexican companies, is due to be delivered at the end of 2011. Enjoy the challenges on site – but beware of dizziness...

TECH SHOW

1 ***An infrastructure showcase***
The Baluarte Bridge is one of the most important projects currently under way in Mexico. It is part of the country's second highway to connect the Mexican Gulf with the Pacific Ocean. The bridge is located in the heart of the Sierra Madre on the highway's Mazatlan-Durango section, which is the final section to be completed. It will reduce travel time on the section from six hours to just two and a half.

2 ***Tough topography***
All of the foundations are formed from footings carved directly into the massive basalt and they need a considerable amount of excavation. The project requires 25km of temporary access roads due to the combination of the bridge's topography and its remote location. All these temporary access roads were designed for the use of trailers. The site entrance is located at 2,000m above the sea level, and the project's low point is at the the Baluarte River below the bridge at about 700m. In between, the main camp is installed at 850m and the bridge deck culminates at 1,100m, 390 meters above the river.

3 ***Mixing steel and concrete***

The bridge is 1,124m long and 22 meters wide, and features a cable-stayed main span of 520m, the longest stay cable span in Latin America, as well as 10 approach spans, varying from 44m to 72m long, four being located on the Durango side and six on the Sinaloa. The approaches and the first 10 segments either side of the main span are made of two lateral hollow concrete boxes connected with transversal steel beams topped with a concrete deck slab. On the central part of the main span, the concrete boxes are replaced by 3m-high steel beams. The pylons have a 'Y' shape up to deck level connected to an inverted 'Y' shape above the deck. All approach piers have an 'H' shape with multiple horizontal struts. The entire bridge deck is at a constant 5% slope.

4 ***Top-free form traveller to drop the full rebar cage***

All of the approach spans are built using the free cantilever method. For this, 20 units of form-travellers have been supplied by VSL and operated simultaneously, 4 at each pier that features the two independent lateral beams supporting the deck structure built in a second phase. The form-travellers were specially designed to meet this particular structure's requirements. They consist of a lower girder supported by a hanger system and a rear support. This provides a working platform and bottom formwork without any structure above, which allows the dropping of the entire prefabricated steel cages in the form, thus shortening dramatically the construction cycles. The inner formwork had to fit within a very reduced section, further impacted at each segment by an inner diaphragm and by the presence of the stay anchorage blisters with a complex geometry, and the external post-tensioning anchorage blisters and deviators. That means that each inner formwork section has to be custom made.

5 ***The highest deck in all the Americas***
The deck reaches 390m above the Baluarte River, making it the highest cable-stayed bridge on the American continents. On the Sinaloa side, pier 9 is 150m high.

6 ***Stay cables from 60m to 270m long***

There are 19 cables in the central span, with lengths varying from 60m to 270m and a maximum of 42 strands. All stays are equipped with friction dampers located just above deck level.

7 ***Special launching gantry***

A special launching gantry is designed to erect the steel deck of the central span. It is capable of taking the preassembled steel structure of the segment with dimensions of 22m by 12m and weighing up to 120t at the back on the erected deck, to move it forwards, and to place it at the tip of the cantilever. After the placing of the segment, the stays are installed and the concrete slab is cast.

8 ***Shared construction responsibilities***

VSL is part of a consortium with three other Mexican companies that was awarded the contract for construction of the bridge and its approaches. VSL is responsible for: the design, fabrication and initial installation of the 20 form-travellers and the 2 main-span gantries; the supply and the installation of post-tensioning and stay cable system for the structure, including the internal PT located in the horizontal struts of the piers; the internal and external PT located into the cantilevers for the approach spans; 1,000t of stays; and the stress bars required to strengthen local areas near the stay cable anchorages on the deck and inside the pylon structures.

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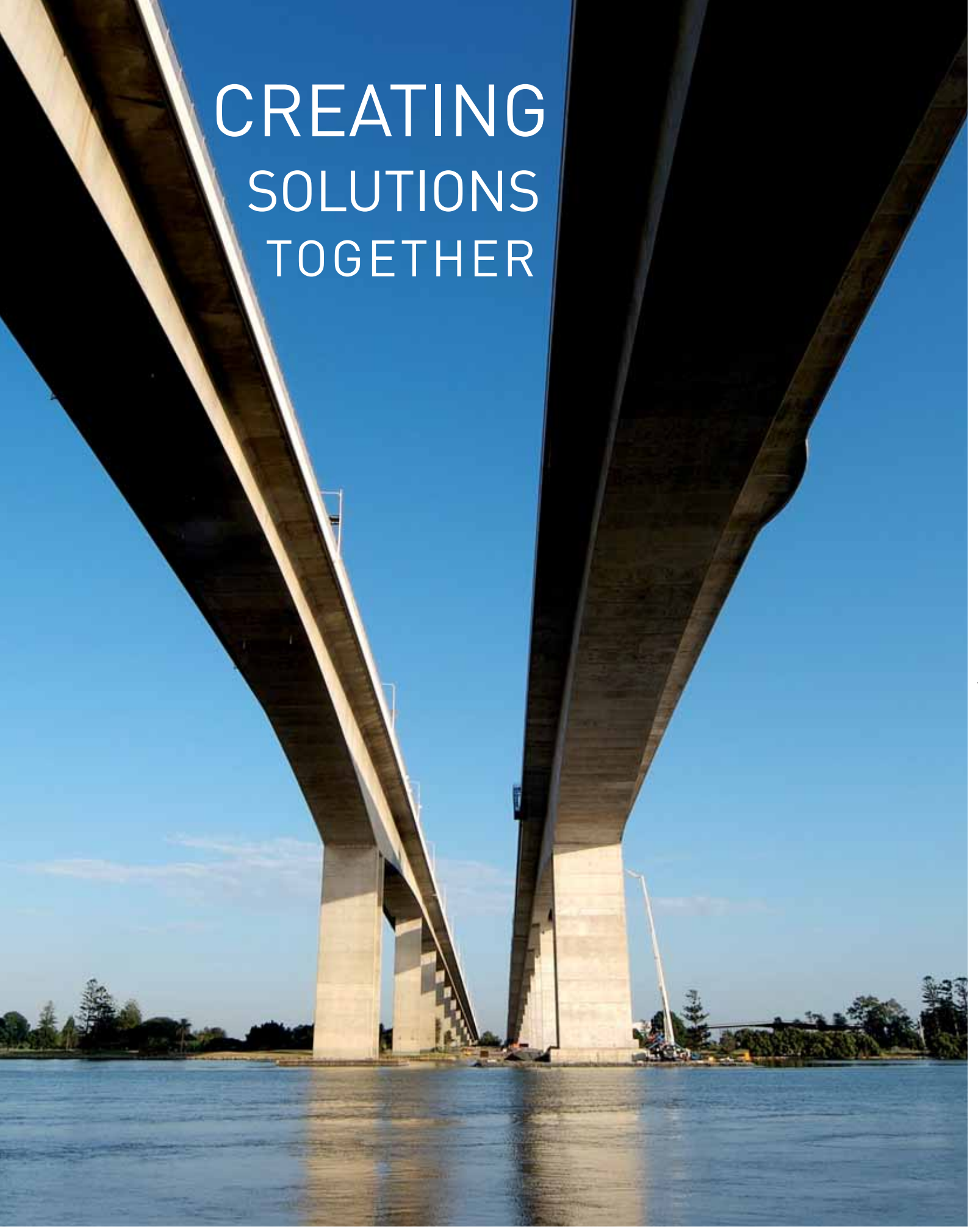

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