VSL news

THE VSL NEWS MAGAZINE • ISSUE ONE 2013

MONITORING OF STRUCTURES

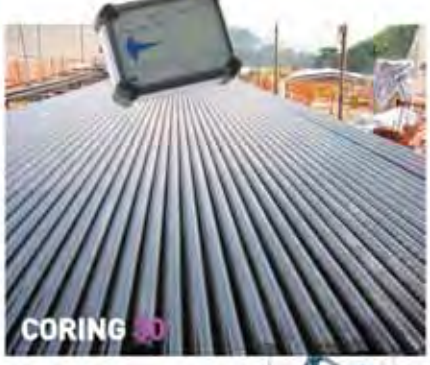
BETTER SAFE THAN WORRY

SPECIAL REPORT

Match-cast segmental bridge piers

ABERDEEN CHANNEL BRIDGE

Full-scope construction



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Anticipating structural behaviour

Daniel Rigout,
Chairman and
Chief Executive Officer

VSL has built its reputation by providing services of high added-value through the technical expertise of its strong worldwide network, backed up by a dynamic R&D effort. From the earliest project phases until the end of a structure's life, VSL's experts provide consultancy and engineering services that produce cost-effective, durable and sustainable solutions for our clients.

The life of any structure is divided into three key phases: planning, construction and maintenance.

VSL's engineers are of invaluable support to designers carrying out feasibility studies at the planning stage, and, if relevant, can propose alternative solutions to achieve what is best for the project. How to build the structure becomes the critical issue once the design is optimised and here VSL's teams take up the challenge to ensure fast-track and safe construction. Monitoring of structural behaviour may be required either during construction or later, when the structure is in service, in order to forecast maintenance works and allocate the corresponding budgets. In each case, our experts respond to the requirements by providing a monitoring system that is adapted to the needs and economic constraints.

Once the inspection plan has been established, VSL can also handle any corresponding strengthening and repair works required.

True turnkey and full-scope projects covering all phases of a structure's life are at the heart of our business.

SUSTAINABLE DEVELOPMENT

Sustainable development at heart

Through its sustainable development strategy, VSL aims to design, build and operate projects that hold the environment, local communities and employees in high regard.

In response to the challenges of sustainable development, VSL implemented a company-wide policy focused on environmental, corporate and social responsibilities at all project stages. Changes were made in 2012, with greater emphasis being placed on sustainable construction. The policy is now organised around four key themes and 12 commitments.

Innovating for sustainable construction

Sustainable construction is at the heart of VSL's research programmes, helping anticipate and keep in step with change. Programmes focus on topics such as energy-efficient buildings, biodiversity and reducing CO_2 emissions and the resources used. With CarbonEco®, a pioneering in-house software tool, it is possible to calculate the greenhouse gas emissions associated with construction and test alternatives.

Ensuring environmentally friendly sites and offices

During construction, VSL seeks to limit environmental impact as much as possible. The company also makes a point of operating its own buildings sustainably, through measures such as low-energy offices, eco campaigns.

Uniting the project team to achieve enduring success

Ensuring that sustainable development is ingrained into our activities means involving all of the project stakeholders – including the customers, other contractors and supplies - in environmental and social objectives. VSL aims to guide its customers towards the most effective solutions in terms of sustainable construction and the well-being of users, by sharing knowledge and jointly developing innovations.

Creating local benefits

VSL puts its commitment to local communities into practice wherever they operate by helping to create jobs, providing help to the most disadvantaged and engaging with local stakeholders.

Guaranteeing the health and safety of employees

Protecting health and safety involves training and empowering employees, improving ergonomics, choosing the right equipment and materials and verifying that any actions required are effective. Ensuring well-being at work involves listening to employees as well as raising awareness among managers about issues such as stress prevention and work-life balance. VSL's values have proved to be highly effective in fostering innovation and a common purpose that benefits everyone. ■

Major challenges in the construction sector

Construction accounts for 40% of:

- the consumption of natural resources,
- energy consumption,
- CO_2 emissions,
- waste generated.

It is essential to develop new methods for design, production, construction and operation, and to adopt a mindset seeking sustainable growth.

Better Life

COMMUNITY ACTIONS

Supporting a local orphanage

VSL Vietnam project staff organised a visit to Hoa Mai Orphanage Centre in Danang, taking with them presents and items of stationery for the children there. ■

Community commitment in Switzerland

In Switzerland, VSL Switzerland's recent community initiatives have included support for the annual nationwide street sale of oranges in aid of *Terre des Hommes*, which helps thousands of children worldwide. The team has also provided *PluSport* - the umbrella organisation for disabled sport in Switzerland – with the annual funding needed to support the activities of two disabled youngsters. ■

Community Day in Vietnam

A group from VSL Vietnam visited a centre for disabled people in Thanh Loc, with donations of money for food, clothes and healthcare. VSL Hanoi's 'VSL VN – Community Day' event was held at a centre for disadvantaged children in the Gia Lam district. Staff from Vietnam and Hong Kong received many hugs in return for the gifts they gave to the delighted children. ■

NEW TRAINING INITIATIVES

Specialised training for bridge erection

A new training programme aimed at developing the next generation of specialist bridge erection engineers and supervisors has been launched at the VSL Academy. It covers the operation of equipment such as launching gantries and is intended to help

VSL maintain its high standards of safety and quality, as well as its excellent productivity. Initially, training is focusing on upcoming projects in Malaysia, Singapore and Thailand. The first 25 engineers and supervisors are mid-way through a three-month programme covering topics ranging from project team organisation to safe and efficient operation of the equipment. Training is led by VSL's most experienced personnel and includes intensive practical site exposures. ■

EXP for quality

The VSL Engineering eXcellence Programme (EXP) is aimed at senior or experienced engineers, particularly those responsible for translating designs and concepts into methods and reality. EXP took place in early June, with a focus on technical requirements and the role of engineers, including the prevention of quality and safety problems. ■

Equipment management

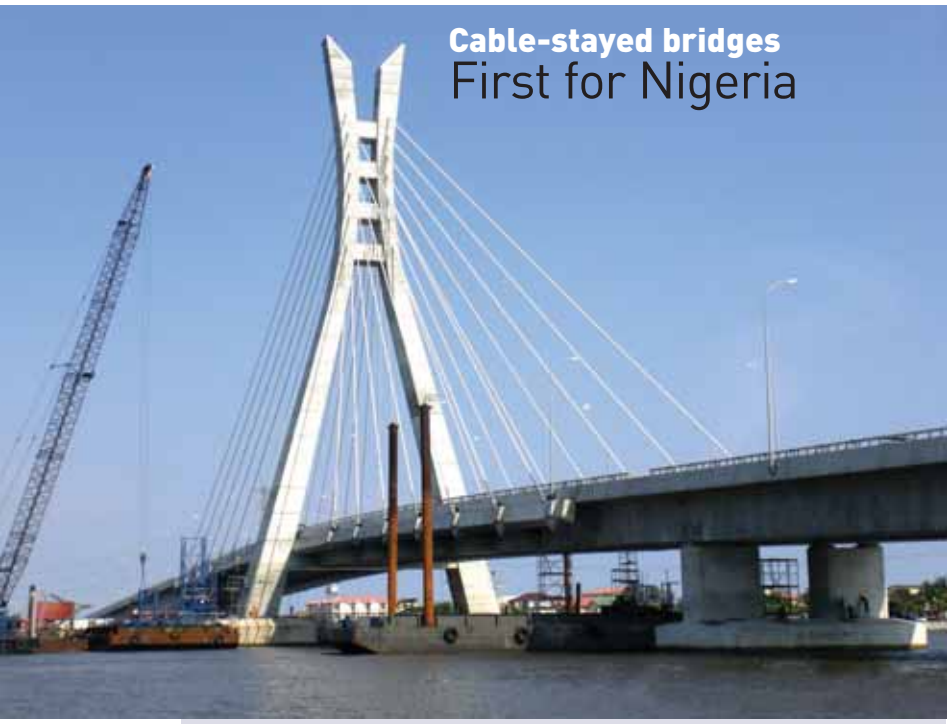
Seven countries have been assessed so far in a new initiative that aims to ensure that equipment management everywhere meets VSL's best practices for safety, use and maintenance. One of the main aspects of the initiative is expert on-site assessment of current practices, together with advice and training. A second focus is the provision of standardised equipment-handling guidelines. ■

UNIVERSITY AND SCHOOL RELATIONS

A live demo by VSL India

VSL India continually strives to improve the standards of post-tensioning in the Indian construction industry. In conjunction with the Society of Civil Engineers and the Department of Civil Engineering of Anna University in Chennai, VSL India held a workshop on post-tensioning for prestressed concrete, attended by more than 400 students and 23 delegates representing leading engineering institutes from across India. ■

facts & trends



Cable-stayed bridges
First for Nigeria

→ **VSL stays have been installed on Nigeria's first cable-stayed bridge.** The landmark Lekki-Ikoyi Link Bridge has been designed and built by Julius Berger Nigeria to relieve congestion around Victoria Island. The 1,357m-long crossing includes a 635m segmental bridge with a 160m main span supported by stays from a 90m-high pylon. Apart from the stays, VSL also supplied Gensui dampers. ■ **Contact: daniel.vieira@vsl.com**

VSoL®
Timber facings

→ **In a world first, VSL has used wood for a VSoL® retaining wall.** The timber-faced structure has been built for a regional road in France. VSL carried out the design of the walls and prefabricated the panels and the galvanised steel reinforcement mesh, as well as providing on-site technical assistance. The wooden panels are formed from 180mm-diameter logs, arranged to ensure structural stability and provide an attractive, natural finish. ■ **Contact: b.chanteperdrix@vsl.com**

Ground engineering
Hong Kong roll-out

→ **Intrafor has become one of the first companies in Hong Kong to introduce a new cutting wheel system** known as 'Roller bits' for construction of diaphragm walls in steep and hard rock. The system was adopted to meet environmental restrictions in creating a three-storey basement for Henderson Land Development. Construction work including 144m of diaphragm walls was needed for Intrafor to deliver the 15m-deep sealed basement, ready for construction of the building above. ■ **Contact: guillaume.lamoitier@vsl.com**

Saddles
Polish record-breaker

→ **Europe's longest extradosed cable-stayed bridge** incorporates the latest generation of VSL saddles. The 808m-long bridge over the Vistula in Kwidzyn is being built for client GDDKia Gdansk by a joint venture of Budimex and Ferrovial to a design by Transprojekt Gdansk. It is the first bridge in Poland with VSL Saddles. ■ **Contact: m.targowski@vsl.com.pl**

Wind turbines
Patented VSL solution

→ **VSL Australia in conjunction with TCAA has a patent currently pending** for its innovative heavy-lift application for lifting and placing windfarm nacelle and blade units. The solution involves the use of a 30t temporary cantilever frame and strand jacking system to install the units on turbine towers.

The frame can be installed using a smaller crane, than the specialist cranes normally used for installation of nacelle and blades. Other advantages of the VSL Heavy lift solution include the ability to lift the rotor, hub and blade elements in one operation and a guide system that extends the acceptable wind speed range for the erection works. ■ **Contact: david.trayner@vsl.com**

Africa
Ivory Coast double

→ **VSL has won two contracts for post-tensioning on the Ivory Coast's Riviera-Marcory project,** which includes Abidjan's third bridge and the Henri Konan-Bédié Bridge. The first contract involves post-tensioning of the 1,500m-long precast twin main viaduct and a 110m long cast in situ twin bridge. The precast viaduct is made from 60 50m-long fully precast girders which are post-tensioned using 700t of strands and floated into position on a barge. The second contract is for the post-tensioning of the Valéry Giscard d'Estaing interchange in Abidjan. Apart from post-tensioning work, VSL is also involved in ground anchors and 4,300m^2 of VSoL® walls. ■ **Contact: antoine.samaha@vsl.com**

Rebuilding Serbian infrastructure
New for old

→ **Azvi has awarded VSL the hanger cable installation work** for the Žeželj Bridge over the Danube in Novi Sad, Serbia. Azvi is part of a consortium including Tadeii and Horta Coslada that is building the arch bridge for Serbian Railways to replace the old bridge, destroyed by bombing in 1999. The project is co-financed by the European Union, the Government of Vojvodina and the City of Novi Sad. VSL's activities are set to commence summer 2013 with the bridge scheduled to open 2015. ■ **Contact: antoine.samaha@vsl.com**

MONITORING OF STRUCTURES

Better safe than worry

The Penang Second Crossing in Malaysia is a 24km bridge comprising a cable-stayed section, with a main span of 250m, flanked by 117.5m-long side spans, with approaches on either side by precast segmental viaducts. VSL was awarded two bridge construction subcontracts that included the supply and installation of the stay cables, the prestressing for the main bridge as well as the supply and installation of the post-tensioning for the approach bridge superstructures.
The contract also included monitoring and the provision of technical assistance.

A long-term strategy for the cost-effective management of infrastructure incorporates a variety of activities such as inspection, instrumentation, observation, testing and investigation. Whether for bridges, such as the Hong Kong Zhuhai Macao Bridge, or nuclear containments, such as the LAES in Russia, VSL provides monitoring systems and technologies that allow the behaviour of structures to be assessed at all stages of their life.

MONITORING OF STRUCTURES

The reasons for monitoring are manifold: experience has shown that each material has distinct ageing properties and may be affected by different external factors. The aggressiveness of the surrounding environment – including pollution, UV, frost, traffic, and also vandalism - can greatly affect the expected behaviour of a structure. Monitoring helps to assess the risks and allows for better planning and optimisation of maintenance, which in turns reduces the overall lifetime costs. At any time, it gives an in-depth view of the structure's condition considering the actual conditions and ageing speed of the structure. Action plans are then defined and implemented accordingly.

Monitoring should be defined and planned at the design stage, where the designer should determine the critical areas with regards to durability that might require special attention, and subsequently propose where and how to instrument the structure. In addition, the frequency of the readings, and what should be the threshold values from where alerts and actions should be initiated need to be determined.

Are expectations met?

One of the main objectives of monitoring is to gather and record information and knowledge about the state of the structure at any given time, and as such to validate the design hypothesis. This helps also to guarantee the structural safety by anticipating any deterioration or damage, and to take the right steps to carry out the appropriate maintenance works at the right time.

The strategy for structural health monitoring must also be tuned to fit with the owner's, operator's and user's needs. Its definition and detailing should be made at an early stage of the design. It is based on the expected service life, which depends upon many parameters, including the design details, materials used, environmental aggressiveness, material fatigue and traffic, as well as envisaged maintenance and inspection works. Involving VSL at this design stage allows optimisation of the monitoring system to fit with that strategy: the client benefits from a professional service based on an extensive experience. Information on the structure's behaviour is provided at the right location at the right time, and made available in real-time remotely. Further compilation and analysis of the data acquired allows the maintenance work to be regularly updated for the plan and carried out at the right time. Consequently, this helps achieve the lowest overall risks and costs. The result is a durable structure with an optimised use of resources.

Monitoring of a VSoL® wall installation

VSL strain gauges measure stress in bars while inclinometers check verticality and piezometers detect any water ingress.

Ask the right questions...

Created in 1984, FT Laboratories Ltd. is an independent specialist VSL subsidiary offering multi-disciplinary laboratory services to the construction industry. It is one of the leading construction laboratories in Hong Kong and has broadened its scope over the last decade to provide services such as tunnel construction monitoring, wind and health monitoring for bridges, ship impact detection and slope monitoring. FT Laboratories helps the client to ask the right questions to ensure that the data provided suit the analysis required. This is of the utmost importance as a single day of monitoring might generate up to 20GB of data which you need to extract the relevant details from to be able to take the right decision.

Vibratest for testing on site

Instrumentation to track changes

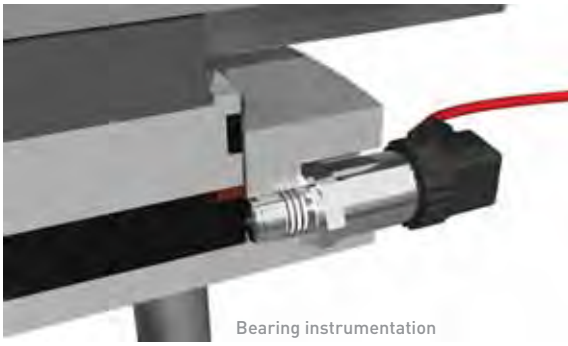
Different tools or systems are required to monitor different parts of a structure for different purposes. When it comes to environmental and weather measurements, VSL selects appropriate sensors to suit the task. For instance, propeller and/or 3D ultrasonic anemometers can be used for wind monitoring. Other parameters that may be recorded include sunlight, rain and humidity. Structures in urban areas may require pollution monitoring and traffic surveys.

VSL's high precision Hc Monostrand load cell can be used to monitor the dynamic vibration of stays. It has been designed to provide information about cable force, cable vibration and the temperature in the anchorage. It has been tested over two million cycles under various loading conditions.

The Vibratest toolset allows quick and inexpensive force monitoring and stay-cable vibration testing on site. It can be used to verify periodically or continuously the stay forces, the stay's vibration mode and the different logarithmic decrements of the stay cables, thus allowing detection of any changes in the stay-cable behaviour or damper efficiency.

For local stress, standard strain gauges provide accurate information. For displacement measurement, as for example between the moving parts at bearings and expansion joints, long extensometers based on displacement sensors or fibre-optics can provide the appropriate information.

An instrumented bearing measures the actual vertical loads that are acting upon it. The purpose of the instrumentation is to detect any changes so that the effect on the structural members can be investigated straightaway. Instrumentation has been developed for both spherical and pot bearings. 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 gather information using wired connections or wireless methods.



Bearing instrumentation

Monitoring was required on the XRL 820 Railway in Hong Kong to verify that the TBM works were not affecting the surrounding buildings and roads. Key parameters such as settlement and vibration were monitored, with alarms triggered if action was needed.

INTERVIEW

Anticipating behaviour for vital decisions

Efficient monitoring systems are invaluable both during construction and throughout the service life of civil engineering and building projects. We asked experts based in Hong Kong for their views on the market and what they look for.

What are the challenges in today's construction industry?

Professor Yi Qing Ni: The construction industry is the second biggest industry contributing to the economy of Hong Kong. With many large-scale construction projects being planned for the next decade in Hong Kong, sustainable development is a big challenge in the construction industry nowadays. Sustainability for built infrastructure and the environment requires innovation, which includes new technologies primed for the construction industry and also new ways of thinking to solve the problems in the construction industry.

Dr Kai-Yuen Wong: Structural health monitoring plays an important role in the provision of essential data and information for planning, scheduling, execution and decision-making throughout a bridge's life, from design and construction through to maintenance, and demolition.

Kevin Diemont: Tunnelling also relies on monitoring. Monitoring during construction of a tunnel is extremely useful because it picks up things that you cannot see. It helps to foresee potential problems.

Where does the critical path for a structural health monitoring and maintenance management system project start?

Dr Wong: It starts with the planning, scheduling, management and supervision of all the instrumentation and associated works, particularly any interfaces with bridge construction. The next steps cover the customisation or development of software, followed by testing to ensure systems behave as required.


Professor Yi Qing Ni

Professor Yi Qing Ni is Professor at the Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University. His research interests focus, among others, on structural health monitoring, dynamics and control and monitoring and control in rail engineering. He is a Council Member of the International Society for Structural Health Monitoring of Intelligent Infrastructure and a member of the organisation committee of the biannual International Workshops on Structural Health Monitoring (Stanford, USA). He is a keynote speaker at conferences on structural monitoring throughout the world and design consultant in the development of structural health monitoring systems.

How are the needs estimated?

Dr Wong: The funding allocated to bridge design and construction usually accounts for an overwhelming percentage of the total budget. But it is important to allocate enough resources for operation and maintenance so that there can be developments in monitoring and maintenance management technologies.

What is the key for a structural health monitoring and maintenance management system?

Dr Wong: One of the key factors for successful implementation is the availability of personnel with the appropriate education, training and experience in the various key technologies related to instrumentation and the gathering, processing, analysis and use of the information. Firm decisions by top management and the availability of sufficient funds are also vital.

You have set up a preliminary geotechnical profile on the CRL 820 and 821 tunneling projects in Hong Kong, thus providing technical support and advice. How exactly?

Kevin Diemont: Our support is in relation to the ground treatment required before the passage of tunnel boring machines (TBMs). For this purpose, we have contracted Intrafor to carry out ground investigation because we want to better understand areas where concerns may arise. Ground conditions may not be as expected. On the XRL 821 project, for instance, the TBM passes underneath a mountain and rock supports have been designed to ensure safety. The role on the XRL 820 scheme involves advising on any ground-related issues and making sure that surrounding buildings are not affected. Monitoring is important throughout the works as it provides the data we need to thoroughly analyse the situation and to give indications to the production team on how to react.

What is the monitoring technology's first benefit?

Dr Wong: The important first step after completing the bridge and its SHM&MMS (or SHMS) systems is to use the technology to validate the design parameters and assumptions. This is essential, as


Kevin Diemont

Kevin Diemont is Geotechnical Manager at Dragages Hong Kong.

decision-making about maintenance of a particular structural component needs to be based on the latest information and assumptions.

Professor Ni: Within the past decade, we have seen a growing interest in the application of sensing technology in engineering and public safety fields. Examples include structural health monitoring, natural/manmade hazard detection and security warning. The rapid progress in sensing technology has developed a variety of novel devices. It is commonly believed by industry and academia alike that advances in sensing technology will have a crucial impact on ensuring infrastructure operational safety and durability.

What makes a good monitoring service provider?

Professor Ni: Multidisciplinary research in SHM has increased tremendously over the past decade. This rapid pace, including advances in sensing, data acquisition, computing, communication, and data management, has made it possible to implement innovative SHM technology for obtaining objective indices on structural conditions and for guiding management and maintenance of infrastructure systems. As a result, a monitoring service provider is expected to offer a package of technologies for structural monitoring, control, maintenance and management. Equipped with innovative sensors and advanced software, such a system is empowered to monitor environmental effects, loadings and structural responses; perceive structural mechanism and deterioration; recognise normal and abnormal operation patterns; control structural behaviour; evaluate structural performance and health status; and guide structural maintenance and management.

Kevin Diemont: Understanding what the client really needs. They will supply the best instrumentation and need to have the experience for proper implementation. In addition, they must be able to respond quickly. In our projects we request availability 24/7. And of course, there needs to be prompt submission of the findings, with real-time results provided.

Dr Wong: I expect a company providing structural health monitoring services to have traceable performance records demonstrating its knowledge and experience in all the areas of technology that are used in gathering, analysing, modelling and using the information. I would choose a monitoring service provider based on a combination of technical competence, sound management skills, a track-record in relevant work, and a good record of professional conduct.


Dr Kai-Yuen Wong

Dr. Kai Yuen Wong has extensive experience in bridge monitoring and retired in June 2013 from Hong Kong Highways Department. He carried out system and performance specification design of the structural health monitoring systems for Tsing Ma Bridge, Kap Shui Mun Bridge, Ting Kau Bridge, Shenzhen Western Corridor, Stonecutters Bridge and Hong Kong Link Road.

Does FT Laboratories make a difference?

Dr Wong: In my view, FT Laboratories differentiates itself from its competitors with its outstanding project management capabilities in tasks such as software development for structural health monitoring and maintenance management systems. I find FT Laboratories to be extremely clever and sensitive in finding solutions to issues and they have a strong 'business mind' in handling structural health monitoring works and ensuring that they comply with the specified technical requirements including establishing partnerships with SHMS specialist contractors and instrumentation suppliers.

Kevin Diemont: FT Laboratories is always willing to start on the work straightaway. No need to wait until all the papers are in place.

Professor Ni: Not just possessing a number of construction-specific test laboratories, FT has also capitalised on the living laboratory of Hong Kong's built environment and the multi-disciplinary expertise of the tertiary institutions in Hong Kong in the field of SHM research. As a result, FT has got the know-how to implement new technologies (especially innovative sensing technology) for sharpening its competitive edge. In addition, FT has devoted itself to the development of customised software systems for SHM data processing, analysis, and management as well as structural condition evaluation. FT is ready to provide professional, creative and productive service in the SHM field.

What is the future of structural monitoring?

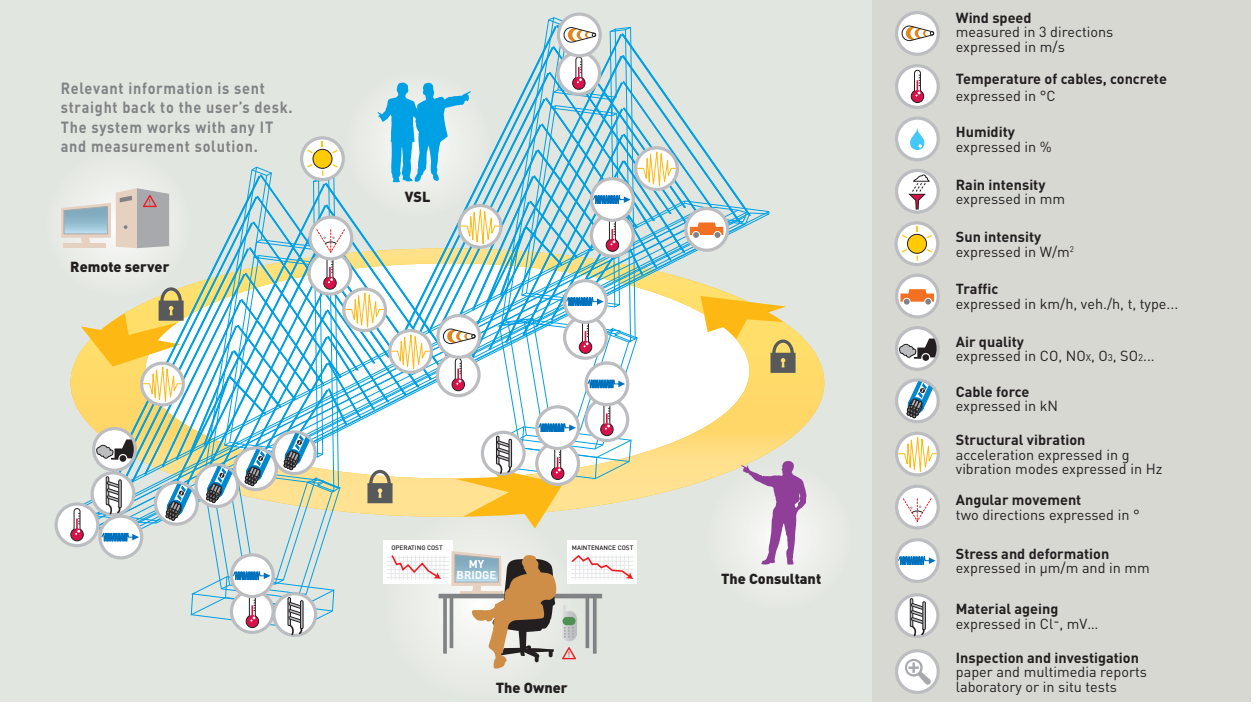
Kevin Diemont: I clearly see an increasing demand for monitoring. People are tending to take less risk; they are only prepared to take calculated risks.

Dr Wong: All bridges inevitably degrade once they are complete and open to traffic. Restoring or maintaining performance requires a combination of regular, preventive and corrective maintenance. But the right decision on a particular maintenance strategy is dependent upon the availability of current and historical information about the structure. The trends of the structural health monitoring market in future should therefore create lots of job opportunities because it is currently the sole scientific means of providing combined subjective and objective information for decision-making on maintenance works.

Professor Ni: Among the many markets available, civil infrastructure systems are emerging to be one of the largest markets for sensing and instrumentation technologies (in Mainland China, all newly built long-span bridges are officially required to be deployed with instrumentation systems). Recently, such works have been extended to the Hong Kong Link Road marine viaduct bridges with the combination of relevant application systems for maintenance management. Hong Kong has a very ambitious infrastructure development programme for the next 10 years. Infrastructure development and environmental remediation programmes in Mainland China are actively pursued. New opportunities have been opened up for our young and enthusiastic graduates. In the application aspect, under the philosophy of condition-based maintenance, SHMS could be applied to highway infrastructure such as submerged tunnels, bored-tunnels, cable-supported bridges, marine viaduct bridges, etc. when and where the cost of preventive maintenance is high and the effectiveness is uncertain.

MONITORING OF STRUCTURES

DeMon is FT Laboratories' **De**formation **Mon**itoring software application for structural and geotechnical instrumentation projects



Typical sensor configuration on a cable-stayed bridge

From structure to desktop

For complex and one-off projects, VSL recommends the installation of permanent monitoring devices and the use of its DeMon system. DeMon is a combination of services to bring together all of the monitoring data – from both instrumentation and inspections – onto the desktop of the owner and engineer, with scope for immediate alerts about any potential problems.

The ultimate in monitoring systems is FT Laboratories' (a VSL subsidiary) Total Structural Health monitoring solution *(see box)*.

A permanent monitoring system generates two types of information: periodic measurements and alerts about exceptional events. The periodic measurements can be used for statistical analysis that allows validation of design hypotheses. Further detailed analysis can be carried out, such as checking the correlation between different sensors, evaluating the fatigue, analysing the mode shape of vibration and determining the wind spectra.

The LAES nuclear power project in Russia required VSL to provide an extensive monitoring system for the two reactor containments. Particular innovations in the project include the use of optical Bragg sensors to allow measurement of concrete deformation and temperature along post-tensioned tendons.

Information stemming from exceptional events can be used to determine issues including the causes of vibration and the effects of severe loads. Consequences of incidents such as high or turbulent wind, storms, seismic events and vehicle accidents can then be fully analysed. If vibration occurs, specific modal analysis can be carried out to determine the cause and develop any remedial measures needed.

Knowledge and understanding to make the right decision

The benefits of a monitoring system are numerous. First, and most importantly, their function of providing adequate safety alerts gives engineers and owners accurate and timely information so that they can take the right decision when implementing actions to deal with these events.
The collection of monitoring data - plus the analysis - allows owners to prioritise and schedule their maintenance programmes.

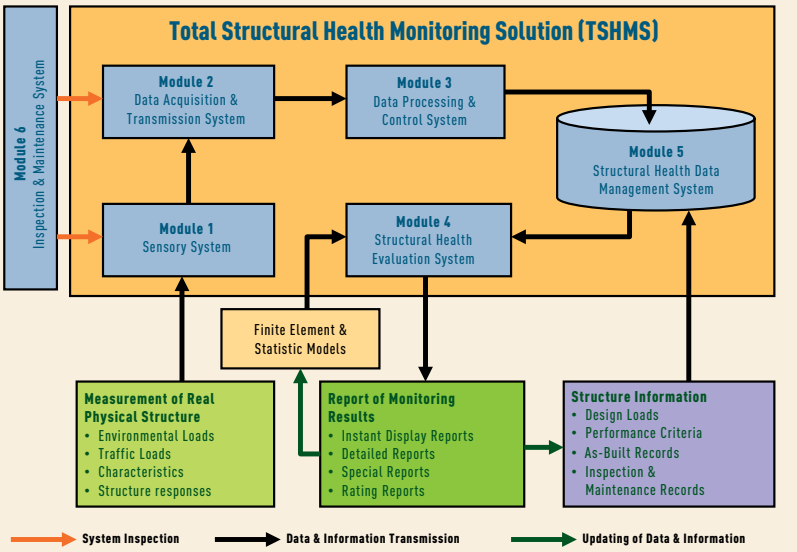
More applications

Management of structures is constantly improving. New sensing technologies and data acquisition

systems allow the hardware to develop and the information to be more accurate. The software also evolves rapidly with the development of the analysis systems, allowing better interpretation and extraction of relevant information. The aim of VSL's monitoring services is to offer tailor-made solutions based on the most efficient technology, the best suited to the final goal. Bridges, buildings, tunnels, nuclear containments, retaining structures and slopes can all be monitored. Permanent monitoring may be necessary for the whole of a structure's life to give real-time information to help schedule maintenance operations. VSL, as a leader in the technology, is constantly developing new sensing systems dedicated to its core business. ■

Total structural health monitoring solution (TSHMS)

Schematic Diagram of FT's Total Structural Health Monitoring Solution

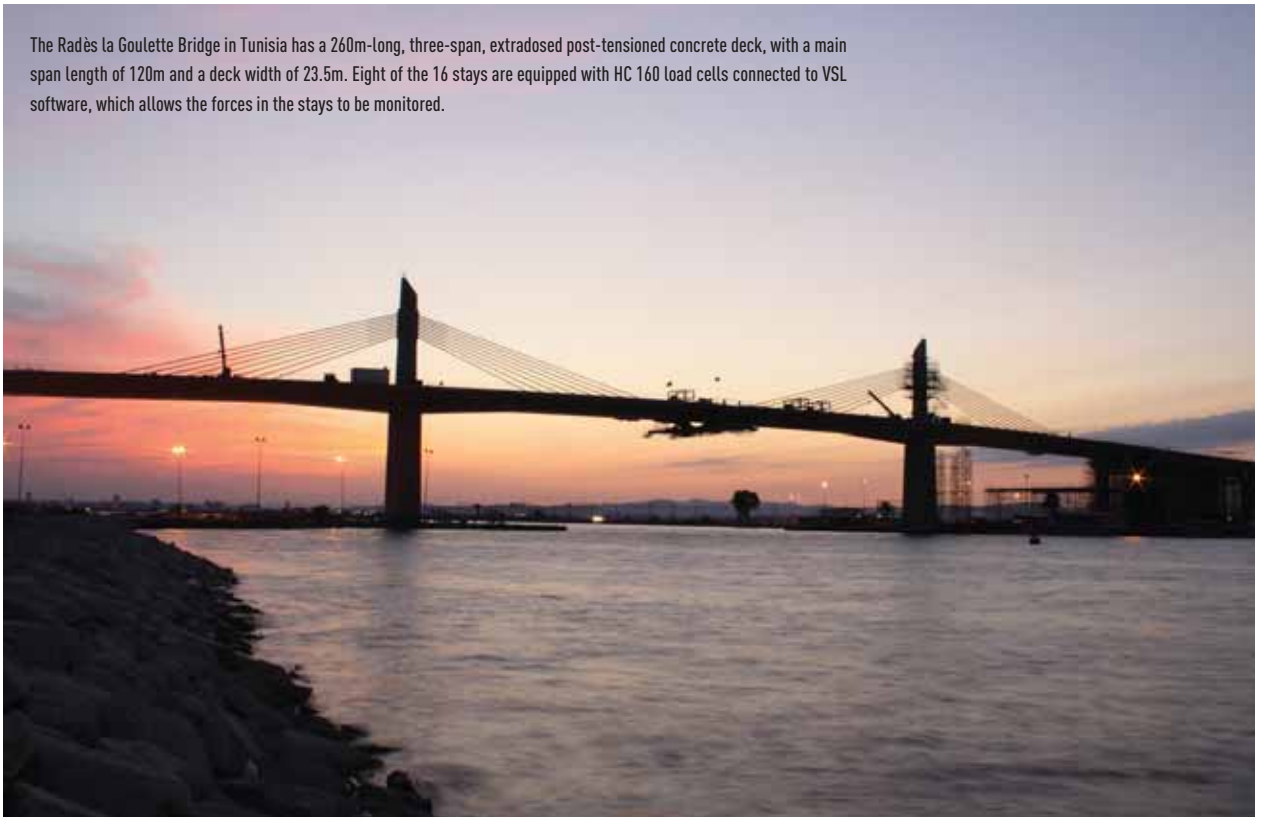


Complex structural health monitoring

The FT Total Structural Health Monitoring Solution is a complete package for the design and implementation needed to meet today's monitoring requirements. It facilitates the planning of structural inspection and maintenance.

The system is used to collect, process and analyse data from the bridge or other structure in order to monitor structural performance and evaluate any identified defects so that remedial works can be planned. It can be implemented gradually from construction onwards as the structure ages, to help optimise budgeting.

The tool also allows operators to carry out inspections of individual structural components and assign a rating that is included with the rest of the monitoring data.



The Radès la Goulette Bridge in Tunisia has a 260m-long, three-span, extradosed post-tensioned concrete deck, with a main span length of 120m and a deck width of 23.5m. Eight of the 16 stays are equipped with HC 160 load cells connected to VSL software, which allows the forces in the stays to be monitored.

site insights

Vietnam

Early completion

→ **VSL Vietnam has completed its work on Nguyen Van Troi - Tran Thi Ly cable-stayed bridge** four months ahead of schedule. The bridge crosses the Han River in the city of Da Nang, 764km south of Hanoi. VSL Vietnam won a major subcontract for key elements of the main bridge including the entire construction of the 127m high pylon, inclided at 12°, together with supply and installation of the stay cables, dampers, bearings and expansion joints as well as a monitoring system. In a first application of the VSL SSI 2000 C system in Asia, 63 stays ranging from 37 to 109 strands were successfully installed. The spherical bearings supplied and installed by VSL hold the record for the greatest load capacity ever known. ■ **Contact: lan.tranduc@vsl.com**

Hong Kong

Expressway widening

→ **VSL is carrying out a wide range of tasks** for the widening of the Tolo/Fanling Highway in Hong Kong. Construction work to build two new bridges using VSL form-travellers was completed in February and most of VSL's post-tensioning, bearing and VSoL® retained earth wall work has now been completed. One of VSL's remaining work is to jack up a bridge for bearing replacement and to adjust its crossfall from -2,5% to +2,5%. ■ **Contact: alan.wong@vsl-intrafor.com**

Taiwan

Dampers for seismic safety

→ **The installation of VSL dampers** in the Shihjia 583 residential building in Kaohsiung City ensures protection against wind- and seismic-induced vibrations. In total, 84 sets of the 1.35m-high wall-type VSL damper system have been installed in 20 of the concrete building's 28 storeys. They are integrated into prefabricated steel panels, which are installed directly in the walls during construction. ■

Contact: johnson.chang@vsl.com

Taiwan

Travelling in Pingtung

→ **Three pairs of VSL form-travellers have been at work** on a major viaduct in Pingtung County. The cable-stayed superstructure of the Bao Li Bridge and Si Chong Bridge has spans of up to 135m. Construction was by the cast-in-situ balanced cantilever method using 100 double-box segments of width 23.1m and depths varying from 2.8m to 5m. VSL's scope included provision of the form-travellers, supervision of installation and commissioning and technical consultancy during operation of the machines. ■ Contact: johnson.chang@vsl.com

Malaysia

Penang's new crossing

→ **The Second Penang Bridge's approach** has 578 spans of 55m-long precast segmental box girders and a cable-stayed main bridge providing a 240m-wide navigation channel. VSL was involved in the post-tensioning works for both the approach and navigation spans, has supplied and installed the VSL SSI 2000 stay cable saddle system for the main spans, which it installed strand by strand with winches, and the dampers. ■

Contact: cheeken.chong@vsl.com

Philippines

High-stakes at play

→ **VSL Philippines has been carrying out post-tensioning** for the Solaire project, the first casino at the 120ha Entertainment City in Manila. Solaire's first phase has 18,500m² of gaming areas along with restaurants and 500 hotel rooms. The project is being constructed by DM Consunji, one of VSL PH's main clients. The two companies have worked together on many projects. ■ Contact: ronan.hasle@vsl.com

Malaysia

Gantry bonanza

→ **Eight VSL gantries will soon be at work** on the construction of Kuala Lumpur's new MRT line. VSL is supplying and operating a total of seven overhead span-by-span launching gantries and carrying out the post-tensioning works on the new Sungai Buloh – Kajang Line. Electrically isolated tendons will be used on the project to minimise current-induced corrosion. Special grout will also be used to enhance the corrosion protection. The objective of the project is to alleviate traffic congestion and decrease travel times in public transport. ■

Contact: cheeken.chong@vsl.com

Australia
Slab upgrade

→ **Work is about three quarters complete on VSL's contract** to build a slab on grade for VicTrack's North Dynon Rail Terminal. VSL Australia designed and built 20,000m² of concrete pavement to replace existing asphalt alongside the rail lines. The 300mm-thick post-tensioned slab can support 30t containers stacked four high, and a forklift with a 101t axle load. Large pours minimised the number of joints, which will bring savings in maintenance. ■ **Contact: Chan.cheong@vsl.com**

Hong Kong
Freeze!

→ **Intrafor has secured a ground-freezing hole-drilling contract** for the West Island Line tunnel. The subcontract for Gammon Nishimatsu WIL JV involves directional drilling of 25 ground-freezing holes and six thermocouple holes, each about 84m long and with a minimum diameter of 200mm. Challenges include drilling at depths 18m below the groundwater table and keeping on target in a high magnetic interference zone where normal guidance systems would not work. Intrafor has adopted the Paratrack PMR system to control the alignment. ■ **Contact: mp.chan@vsl-intrafor.com**

Australia
Piling in Perth

→ **A final rail shutdown will see VSL Intrafor complete all of its work** on the Perth City Link Rail Alliance project. Work by the VSL Intrafor/AVO Piling JV primarily involved a diaphragm wall and piling but the site conditions also dictated the use of techniques including mini-piles up to 600mm in diameter and 38m deep. Most of the mini-piles had to be drilled in limited-access areas, including inside Perth Station. ■ **Contact: steve.mills@vsl.com**

Australia

Heavy-duty slab

→ **VSL has completed a slab-on-ground project** at DP World's West Swanson Intermodal Terminal at the Port of Melbourne. The contract involved the design and construction of 7,500m² of 250mm-thick post-tensioned slab on ground to support equipment including straddle carriers, containers, container trucks and forklifts. Aggressive vehicle braking and turning meant that the original asphalt was wearing out and becoming rutted. The post-tensioned solution provides a hard-wearing pavement with few joints and minimum maintenance. ■ Contact: Chan.cheong@vsl.com

Australia

Mega success

→ **The VSL Lucas JV has built a 32,000 m³ water storage tank** in Harvey, Western Australia. Constructing the 56m-diameter, 13.6m-high tank for the state water authority, WaterCorp, has involved extensive drilling, blasting and earthworks. VSL's precast post-tensioned tank system offered technical and commercial advantages, including the use of a single joint-free pour for the prestressed base slab and ring beam. Using full-height precasting for the 64 wall panels and 24 roof columns, which were cast off-site significantly reduced the amount of labour and equipment required on site and allowed to overlap earthwork with casting. ■ Contact: chan.cheong@vsl.com

Australia

Deck launch success

→ **The first of two bridges deck launches on the Newcastle inner city bypass has been completed.** The launches are critical to the project's success as they have to be completed during fixed rail shutdowns. VSL Australia was awarded the subcontract for design engineering assistance and the provision of equipment and technicians for the launches. The 1,400t northbound carriageway was jacked over the railway using two SLU70 strand jacks. Launch speeds reached 15m an hour. ■ Contact: Mark.withers@vsl.com

NOTE PAD

Tanks in hand. VSL Australia has won the post-tensioning subcontract for two more LNG projects, taking its total cryogenic work in hand to eight tanks. The latest projects involve the post-tensioning of two LNG tanks of 140,000m³ capacity each on the QCLNG project in Queensland and the post-tensioning of two LNG tanks of 160,000m³ capacity plus two LPG tanks on the Ichthys project in Northern Territory.

Cool water. VSL Malaysia has completed the supply and installation of 265t for the horizontal post-tensioning of a chilled water tank at Putrajaya in Malaysia. The 54,000m³ capacity tank stands 34m high, with an internal diameter of 45.5m and a wall thickness of 750mm.

Taiwan school. Nanshan High School in New Taipei City is being equipped with 14 sets of VSL wall-type dampers to protect against seismic induced vibrations. The dampers are being installed in the first seven floors of the 10-storey building, which also has two basement levels. Each set contains a single viscoelastic damper.

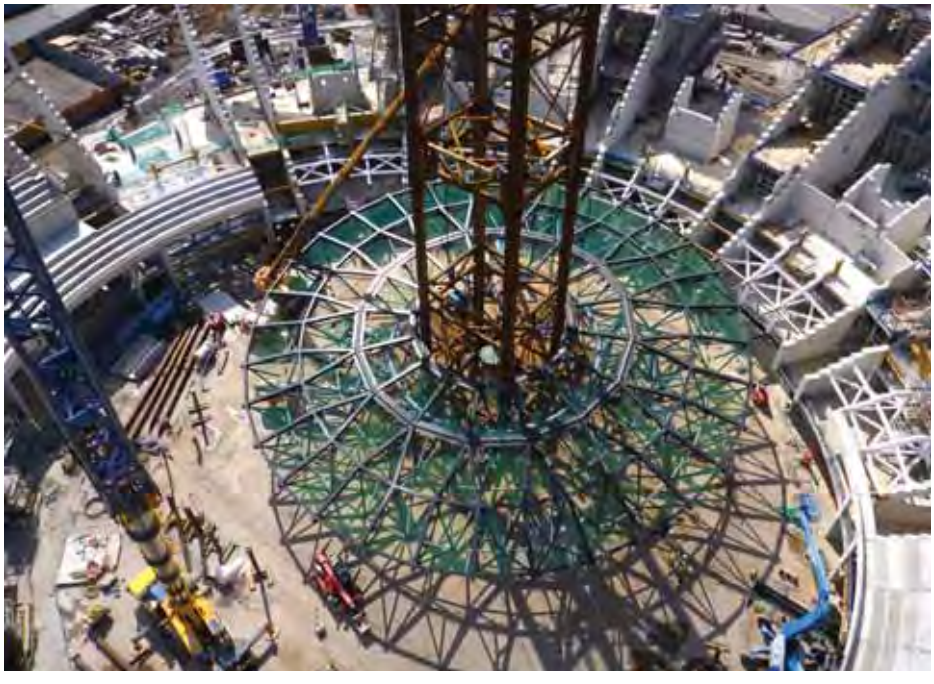
City HQ. VSL Vietnam is carrying out the supply and installation of 200t of prestressing for slabs and beams of the 35-storey Vietcombank Tower in downtown Ho Chi Minh City. It will become the Vietcombank Ho Chi Minh City branch headquarters.

Sensitive solution. Intrafor has completed a challenging grouting and ground improvement contract in Hong Kong. The TBM for MTR's Express Rail Link passes under old buildings at Tai Kok Tsui, sensitive to ground movement. The team drilled, installed and grouted tubes a manchettes up to 35m deep, enabling the TBM to complete the tunnel works ahead of programme.

UAE

On the road again

→ **The Road & Transport Authority of Dubai has restarted construction of the Trade Centre Bridge** after the project was put on hold two years ago. VSL Middle East had been awarded the post-tensioning work for the cast-in-situ and segmental bridges in 2008. Completion has now passed 70% and the project should be finished by the end of the year. VSL is supplying and installing 2,500t of prestressing which includes VSL's latest GC Anchorage system. ■ **Contact: sburke@vslme.ae**



Scotland

Lifting the light ring

→ **The final lift has been completed for the roof of Glasgow's new multi-purpose arena.** The 12,000-seat arena is one of the main venues for the Glasgow 2014 Commonwealth Games. VSL was responsible for lifting the 340t centre roof with a clear span of 46m. It initially raised the roof 1m, rotated it 6.4° and then lifted it about 40m into position. The final operation in March involved lifting the 245t light ring. ■ **Contact: Lars.schoenlein@vsl.com**

USA
Synchronised jacking

→ **VSL was awarded the contract to lift a 300m-long ramp** for the renovation of the I-595 flyover in Miami. The 2,360t ramp was jacked up by about 0.5m in several steps. Use of VSL's VSJS synchronised jacking system enabled the complete operation to be monitored and controlled, with individual adjustment capabilities of each jack. ■ **Contact: Josemaria.martinez@vsl.com**

UAE
Hospital of the future

→ **VSL Middle East has completed the supply and installation of post-tensioning** for the Cleveland Clinic Abu Dhabi. The 364-bed state-of-the-art hospital will provide a seven-star experience for patients from the UAE and abroad. All aspects of the post-tensioning complied with requirements set by the Sixco-Samsung JV's LEED team as the building is targeting Gold certification. The green construction practices brought benefits to the workers' productivity and health while protecting surrounding ecosystems. ■ **Contact: sburke@vslme.ae**

UAE
Another high for Dubai

→ **Dubai's tallest soil wall project has been completed by VSL Middle Eas**t as part of improvements to a major expressway. The VSoL® Retained Earth wall system was used for ramps on Al Khail Road. A total of 20,784m² of VSoL® was erected throughout the interchange, with sections reaching 17m in height. Aecom managed the Road & Transport Authority project. ■ **Contact: sburke@vslme.ae**

Poland

Stringent demands

→ **VSL's anchorages have met the stringent fatigue demand**s for an S-shaped cable-stayed bridge in Torun town. Strabag is main contractor for the 296m-long bridge, which has spans of up to 80m and is supported by 52 stays. The viaduct's double horizontal curves create significant geometrical deviations in the stay anchorages. Designer Pont-Project specified that the stay system required fatigue resistance above the standard fib requirements. A fatigue test demonstrated that VSL's anchorages meet these more stringent requirements. ■

Contact: m.targowski@vsl.com.pl

France

GC for LNG

© Dunkerque LNG SAS

→ **The Dunkerque LNG terminal built by Bouygues Travaux Publics** marks the first French application of the ETAG-approved VSL GC anchorage system using 12 and 19 strands. VSL is in charge of post-tensioning work for three tanks with a total capacity of 570,000m³. Before the commencement of grouting operations, five tendons were fitted in a full-scale mock-up that replicated the greatest tendon deviations on the project. VSL also deployed its new high-performance VSL Medi mixer at the project together with the latest version of its new DAS Data Acquisition System which provides real time information and record of all stressing parameters. ■ **Contact: antoine.samaha@vsl.com**

France

Bridge facelift

→ **The cable-stayed Saint-Nazaire Bridge spans the Loire River** and the entire 3.3km structure is being renovated. The bridge has 52 piers and the project requires the repeated installation of two different types of working platforms at each span. VSL is carrying out 112 lifting and lowering operations to position the 150t and 350t platforms. ■ **Contact: marc.winkelmann@vsl.com**

Russia

Preparing for the Games

→ **VSL and SK Most are nearing completion of a cable-stayed bridge** that is part of the access route for the coming Sochi 2014 Winter Olympics. The 800m-long bridge has a 312m main span, suspended from two 86m-high pylons. The long-span cable-stayed solution was chosen to minimise risk of landslides and impact on the river landscape. ■ **Contact: julien.violle@vsl.com**

Switzerland

Hoist stinger support

→ **Doubling of the Veytaux hydroelectric station's power output** requires excavation of a 1.5km-long connection leading into a cathedral-sized cavern. VSL was responsible for the supply and post-tensioning of both temporary and permanent anchors to support the hoist stinger used for maintenance. The project represents a real challenge as it is located just a few metres away from the main road, the railway and Lake Geneva, and directly underneath the Chillon Viaduct's 45m-high piers. ■ **Contact: christophe.candolfi@vsl.com**

Switzerland

Underground challenges

→ **The output of the hydroelectric station at Emosson Dam** is being increased and a new cavern 600m underground will house the future pumped storage plant. VSL is fabricating and stressing temporary anchors to maintain the roof during construction of the gigantic 190m-long by 52m-high cavern. The anchorages are inclined towards the top which poses the greatest technical challenge, while operational challenges come from access restrictions and limited lifting capacity when working underground. ■ **Contact: Christophe.candolfi@vsl.com**

Brazil

Rio stadium revamp

→ **The Maracana Stadium was once the world's largest stadium** and had a capacity of 200,000 seats. It is currently being modernised for the 2014 FIFA World Cup in Brazil and the Rio 2016 Olympic and Paralympic Games. VSL has just finished lifting the complete cable-net roof structure in one operation that was carried out in two steps using 60 lifting points. The 203,000m² roof is one of the largest in the world and will cover the stadium's 80,000 new seats. ■

Contact: Lars.schoenlein@vsl.com

Mexico

PT for WWTP

→ **The Agua Prieta wastewater treatment plant (WWTP)** is designed to process most of the sewage from the metropolitan area of Guadalajara. VSL Mexico has supplied and installed 300t of multi-strand post-tensioning for three digesters at the plant. The project's target is to achieve integrated and sustainable management of the region's wastewater to the benefit of the lakes, streams and aquifers. ■

Contact: mmartinez@vslmex.com.mx

Brazil

Getting ready for the World Cup

→ **VSL raised the cable-net structure of the new Fonte Nova stadium in Salvador da Bahia** in an operation that spanned from May to November 2012. Tensioning and lifting of the cable-net roof took place in two steps, using strand jacking units with a total pulling force of 53,410kN. The old stadium had to be replaced as it did not meet FIFA's standards for the 2014 World Cup. ■ **Contact: lars.schoenlein@vsl.com**

Spain

Giant bearings

→ **VSL has designed and supplied giant bearings** for the Ricobayo Viaduct on the high-speed railway between Madrid and Galicia. The longest of the viaduct's four spans is 155m and the deck was built by the balanced cantilever method. VSL provided both 'PL' free bearings and 'PU' unidirectional bearings. The large bearings, with diameters up to 2.4m, are designed for a vertical design load of 100,000kN – in the case of the PU bearings – in addition for a horizontal design load of 11,000kN. ■ **julio.garcia@vsl.com**

Mexico

Tallest tower

→ KOI Tower in Monterrey is set to become Mexico's tallest building and one of the highest in Latin America. The 267m-tall office, hotel and residential tower is being developed by Internacional de Inversiones and built by Docsa. VSL will construct 172,750m² of post-tensioned slabs for the 61-storey structure. The 30-month project will use 400t of VSL's unbonded mono-strand system. ■ **Contact: mmartinez@vslmex.com.mx**

Spain

Without a hitch

→ **Cosentino, a leader in natural stone products, is expanding its plant in Cantoria** and turned to VSL for construction of a 10m-high wall. VSL Spain's contract involved the supply and installation of 1,900m² of VSoL® for the wall. Facings are made from 2.25m by 1.5m concrete panels and galvanised mesh is used as reinforcement. Erection had to be carried out quickly and VSL installed an average of 65m² each day to meet the tight time constraints. ■ **Contact: elena.gil@vsl.com**

NOTE PAD

Precision jacking. VSL has carried out extensive jacking at Barcelona's Sants Railway Station for the high-speed railway. Work included jacking up five existing piers and five new trusses in a complex series of operations using the VSL Synchronized Jacking System (VSJS) to achieve tolerances within tenths of a millimetre.

Weight lifting. VSL has carried out several operations relating to the replacement of a reactor vessel head at Vandellós power plant. The VSL Skidding System (VSS) was used to move the 60t head temporarily so it could be weighed. Lifting the head required the development of a customised connecting device.

MATCH-CAST SEGMENTAL BRIDGE PIERS

Fast, efficient, convenient

VSL's experience in precast segmental bridge erection combined with the advantages of precast pier fabrication allows the client to save time and money while at the same time presenting quality advantages when using elements cast under factory conditions.

Construction of bridge piers is often carried out in close proximity to live rail or road infrastructure in difficult weather conditions and under tight programme constraints. VSL fabricates bridge piers in the factory-like environment of precasting facilities. Precast fabrication allows piers to be erected in a fraction of the time taken by conventional in-situ casting - in some cases an entire pier can be assembled in a single night shift. This provides significant programme gains as well as minimising the impact on the public by reducing the window needed for lane closures or rail shutdowns. There are also quality advantages with elements being cast in protected factory conditions, isolated from adverse weather.

Avoiding spilling

The system is made up of two main components: the precast concrete elements and the post-tensioning. Precasting and post-tensioning are part of VSL's core technology and skills. The precast bridge pier/crosshead elements are cast in segments and ducts for the vertical post-tensioning, which uses VSL Stressbar or multi-strand tendons, are embedded in the segments. The precast segments are 'match cast' to eliminate any requirement for a grouted 'wet' joint between segments. The precast segments

Promoting new ideas across the VSL network

As part of the Hunter Expressway project in New South Wales, VSL Australia's engineering team developed an innovative new formwork system for precast concrete columns. Highlights of the project included the deployment of this new formwork system as well as the use of a 165m-long launching gantry to erect 75m-long spans. Construction involved precasting column and bridge segments, erection and post-tensioning of columns and installation of permanent bearings. After the application on Hodariyat Bridge, Hunter Valley and Seaford bridges were the first projects in Australia where the VSL multi-strand tendons were used for prestressing of precast piers.

are erected and assembled on site and "stitched" together with VSL Bars and/or strand tendons reeved through the ducts. The post-tensioning effectively connects the pier segments to the foundation below and the crossheads above to form a homogenous structure. The length of the precast pier segments is controlled by set-up in the casting yard, transport restrictions and available cranes.

Segments are delivered to site, where they can be stacked very quickly by crane on the cast-in-situ pile caps. After stressing, the piers look and behave exactly as a conventional pier would. Precast elements are particularly advantageous for bridges constructed over water, wetlands and other sensitive areas where environmental considerations discourage casting on site to minimise the risk of spillage. Traditional bridge construction requires significant access underneath the bridge for both workers and equipment. Site conditions and construction constraints can vary significantly between projects. Some sites are in rural areas where traffic is minimal but distance makes it expensive to transport wet concrete. Others are in congested urban areas where space is limited. Work may be taking place at high elevations over water. Precasting of concrete elements addresses many of these issues by allowing tasks to be performed off-site.

Ensuring high quality

"Precast concrete elements are often more durable and of more uniform quality than their cast-in-situ counterparts because of the controlled fabrication environment and the strict quality control in the casting yard.", says Chan Cheong, VSL's precast products specialist.

Casting off-site - generally done under cover – ensures more accurate reinforcement placement, better concrete vibration for compaction and mould alignment. For piers subjected to significant bending, durability is improved through the use of the post-tensioning, which keeps the precast pier under compression. This reduces the amount of concrete cracking.

Precasting operations are well established, repetitive and systematic. Effective curing of precast concrete can be more closely monitored and achieved in the factory than on the construction site.

Significant reductions

Fabricating a substantial part of the structure off site significantly reduces the amount of on-site construction labour, materials and equipment required. The need for on-site formwork and scaffolding, reinforcement fixing and concreting is eliminated. All that is needed are the resources in labour and equipment (cranes and boom lifts) for the erection of the precast segments as well as the installation, stressing and grouting of the post-tensioning. As a consequence, costs and environmental impact are reduced while safety is improved. The approach is particularly suitable for remote sites where it is difficult and expensive to source labour, materials and equipment.

Fast-track construction cycles

A shorter construction programme is achieved as the superstructure elements can be manufactured at the same time as earthworks and foundation construction are taking place on site. Exposure to bad weather is significantly reduced as most of the actual construction – the precasting - is done under cover. Hence, precasting significantly reduces the risks of downtime due to inclement weather. A typical precast pier can be erected in a significantly shorter time than an equivalent pier cast-in-situ.

Introducing precast piers in Hong Kong

VSL Hong Kong, together with Dragages Hong Kong and China Harbour Engineering, is building the Hong Kong – Zhuhai – Macao Bridge. This section of the Hong Kong Link Road (HKLR) is 9.284 km in length. Over 7.5 km of the bridge runs over the sea and the last 1.7 km above the seawall along Chek Lap Kok South Road.

The bridge foundations will be built with bored piles. The typical columns will be precast and the superstructure will adopt precast segmental construction method with overhead balance cantilever erection girders and lifting frames. Continuous improvement of technology and a proven track record from previous projects convinced the client to use a precast pier solution.

Furthermore, once erected and stressed, the precast piers can support the superstructure without need for further on-site concrete curing. In-situ concrete piers would require a minimum time curing prior to being able to accept superstructure loads.

Reduced traffic disruption

Bridge construction, especially in high density urban areas, often contributes to traffic delays and congestion. This is caused by on-site construction equipment (formwork, material delivery trucks, pre-mix concrete trucks, concrete pumps, etc.) and labour. Precasting takes a large part of these elements away from the site, thereby significantly reducing traffic congestion and disruption.

Enhanced safety

Last but not least, bridge construction sites often require workers to operate close to high-speed traffic, at high elevations, over water, near power lines, or in other dangerous situations. Use of precast elements significantly reduces the amount of time workers operate in a potentially dangerous setting. Working platforms/scaffolds can be securely attached to the precast segments as they are erected, reducing the need to install access systems at height.

Lower overall costs

Precast concrete bridge elements can bring down the overall cost of the bridge once the reduction in construction delays is factored in. In the past, these costs were often omitted from estimates, which made the use of precast elements appear relatively expensive. New contracting approaches which consider the real overall costs are expected to demonstrate that the use of precast concrete components is very competitive. The greater durability achieved through precasting in controlled conditions can also bring long-term maintenance savings.

Since the Moorabool Bridge project in 2007, VSL has successfully completed many bridge, viaduct and aqueduct projects of varying size and complexity using the precast pier system. Precast piers have also been adopted in other VSL projects outside of Australia, such as Hodariyat Bridge in Abu Dhabi or the Hong Kong – Zhuhai – Macao Bridge. This is yet another example of how VSL's solution network culture successfully transfers new technology to its clients throughout the world. ■

VSL's first precast pier project in 2007: Erection of precast pier segments at the remote Moorabool Bridge site in Geelong, Victoria.

Precast solution to minimise temporary works

The 1,300m-long Hodariyat Bridge was built across a sea channel to connect Abu Dhabi to one of its islands. VSL, together with the designer, developed the design and methods for the use of precast elements. All the elements were precast at the site and handled by gantry crane or barge crane. Precast elements for the piers were joined using stressbars positioned between adjacent segments. Final permanent post-tensioning was then applied from the pier head down to the pile caps. The use of precast shells for the piles caps enabled fast production rates and reduced the amount of temporary works and formwork needed in the water. Use of precast columns avoided problematic logistics during concreting. The precast solution eliminated the need to handle formwork in marine conditions and enabled a fast pace of work in a safer environment while producing a high quality finished project.

Minimising traffic impact

On the M80 upgrade project, the Tulla Sydney Alliance awarded to VSL a subcontract to supply and prestress precast piers for three bridges. This comprised a total of 79 Pier segments and 28 crosshead units. At VSL's Thomastown precast facility, a specific casting bed was established to cater for the heavier segments (up to 98T), which allowed the segments to be slid onto the transporters, without need for cranes. Some of the piers are directly adjacent to and on the median of a live motorway. With the pre-cast pier construction method VSL was able to erect each pier in a single night shift meaning short term lane closures only, and during off-peak. The piers went up fast, and the minimal impact on the public traffic helped to minimise the impact on the community at large.

Short line casting method

GEOMETRY CONTROL

The art of curved alignments

VSL is now spearheading the development of a new software to manage the geometry of precast segments during the casting process.

The challenge of building a precast segmental bridge lies in the fact that the segments are manufactured away from where the structure will eventually stand. It is of utmost importance to transfer the bridge geometry accurately to the casting yard. The purpose of geometry control software is two-fold: to define the theoretical geometry of the bridge and its segments, and to process survey data throughout the casting process.

There are two different methods of match-casting precast segments. The long-line method involves setting up a casting bed for an entire cantilever or span. Segments remain stationary and formwork is moved along, which means that the geometry control is relatively straightforward as the whole span or cantilever can be surveyed. However, long-line casting is only suitable for straight or regular alignments.

For curved alignments, segments are usually cast using the short-line method. Each segment is cast in stationary formwork against the previous element, which is then removed, allowing the new segment to take its vacated position. The next segment can then be cast within the stationary formwork. Segments have to be surveyed carefully before separation. Analysis of the survey data identifies any casting errors and determines if adjustments are needed in the setting-out coordinates for the next units.

Abes GeoDes and Abes GeoCon

VSL's first involvement in geometry control software goes back to Seoul Expressway project in South Korea in 1990. Since, VSL has partnered with software engineers to continue to develop software to model bridge alignment, segmentation and control points and to make checks at the casting yard. Abes GeoDes and Abes GeoCon packages are the latest results of such software development and allow modelling of more complex structures.

Abes GeoDes provides tools for the modelling of alignment, cross-section and segmentation of segmental bridge decks. Bridge segmentation is modelled through modular groups that represent cantilevers or spans. Each segment group consists of a sequence of segments of one of four basic types: precast, in-situ, wet-joint or expansion joint, hence giving the engineer full freedom to define a segmentation and casting direction most suited to cell design and segment production sequence.

Abes GeoCon supports geometry control during the casting process. It provides setting-out coordinates for the segments and bulkheads and is also used to interpret survey data after casting. It verifies data and checks for casting errors and then calculates any corrections needed for the next segment. It supports any kind of survey measurements like the traditional method using local coordinate system per casting cell or more advanced methods based on capturing positions of survey points by measuring their global coordinates.

Modelling along a 3D curve

This new software is not limited to precast segmental construction. The ability to model detailed cross-sections along a 3D-curve enables it to define, for example, the complex geometry of cast-in-situ bridges, long-line cells or the complex shapes of the beams used in monorails.

VSL has already used the software successfully on three bridge projects and it is currently being employed to model more than 20 alignments for a combined rail-road viaduct and its ramps. ■

HORIZONTAL DIRECTIONAL CORING

Follow the path

Clients, consultants, contractors and subcontractors all rely on early access to accurate geotechnical information in order for their projects to be a success. Intrafor uses the latest horizontal directional coring technologies to deliver ground investigations that equip project teams with the knowledge they need.

High quality information about ground conditions is crucial for tunnelling schemes where conditions may vary significantly along the route. It is of vital importance to know the ground conditions in advance and, more importantly, the locations of faults, groundwater and any large fissures with soft infill materials. This information dictates the choice of construction methods, which in turn defines the programme, the resources needed and the costs.

In complex ground conditions, horizontal directional coring provides the level and quality of information required to build tunnels successfully and safely: no section is left unknown and solutions can be developed before excavation starts. Intrafor is one of the world's leading specialists in this innovative ground investigation technique.

The cores are retrieved using Intrafor's directional barrel. The drill rod is aligned using multiple deviation bearings. The diamond coring bit has a swivel arrangement, which enables the drill rod to turn while the core-catcher and outer casing remain stationary. A borehole survey probe is used to check the alignment in 3D.

The traditional approach for tunnelling projects relies on drilling vertical or sub-vertical holes to depths just lower than the invert level of the tunnel. Soil and rock samples are recovered for laboratory testing to determine engineering properties and parameters for the subsequent design works. Very often, field-testing is also carried out. Use of such methods as part of a comprehensive geotechnical site investigation generates adequate information for most civil engineering projects such as foundations or slope stabilisation. However, for tunnelling projects in particular, especially those in marine environments where there is only limited information available from surveys or desk studies, other techniques may be more appropriate.

Continuous rock core samples

In its quest to push the limits of construction, Intrafor - VSL's specialist ground engineering services subsidiary - has progressed beyond the traditional soil investigation techniques carried out from ground level. Intrafor was already a renowned expert in this field and has gone on to develop sub-horizontal directional coring techniques. It has used the technology to achieve directional sub-horizontal coring lengths of more than 1,100m along the routes of tunnels.

Long cores supply the answers
Intrafor's steerable long-hole coring method is attracting considerable interest among tunnel designers in Hong Kong. It will be used to gather information about the complex geology of fault zones at the ends of a 5.5km-long drainage tunnel to be built from Tsuen Wan to Ting Kau. The advanced technology enabled core holes of 935m and 660m to be drilled.

Horizontal directional coring provides design engineers with an accurate insight into the geological conditions along a tunnel's route. It is a drilling method that allows the drill to follow a pre-determined trajectory within a specified tolerance envelope, while also recovering rock cores. The technique provides a continuous rock-core sample along the entire tunnel alignment, giving detailed geological information before construction starts. Horizontal directional drilling can also identify any permeable zones with high water flux.

The drilled hole can be compared to a miniature 'tunnel' and its water flow can be used to predict the inflow during tunnel construction.

Along a curved alignment

The horizontal directional coring technique has two main components: the steering device and the surveying instruments. It is difficult to drill a long horizontal hole to the correct alignment without active directional control.

Intrafor's objective 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. The use of Intrafor's steerable core barrel enables continuous coring that follows a predetermined alignment to ensure correct assessment of the ground conditions. In particular, Intrafor wanted to be able to provide continuous rock coring along a sub-horizontal curved alignment for ground investigations on projects such as tunnels and mines.

Check tunnel alignment
The Harbour Area Treatment Scheme is a world-class sewage collection and treatment scheme. HATS Stage 2A upgraded the preliminary treatment works around the northern and southwestern shore of Hong Kong Island and constructed a deep tunnel system to convey the untreated sewage from Hong Kong Island to Stonecutters Island Sewage Treatment Works. Inclined direction controlled drillholes were drilled to follow the proposed sewage tunnel alignments for the project. Soil and rock samples were recovered to provide geological and geotechnical information for the subsequent sewage tunnel design.

Prepare improvement works
A new boundary control point (BCP) in the border area of North-eastern New Territories required site formation works for about 23 hectares of land, provision of BCP buildings and associated facilities, construction of about 11km long dual 2-lane truck road, improvement works to a 4.5km long section of the Shenzhen River and the associated landscaping works. The works mainly comprised land ground investigation including trial pits, drillholes, horizontal directional coring, boulder investigation, geophysics surveys, in-situ testings, field measurement and laboratory testing of soil and rock samples.

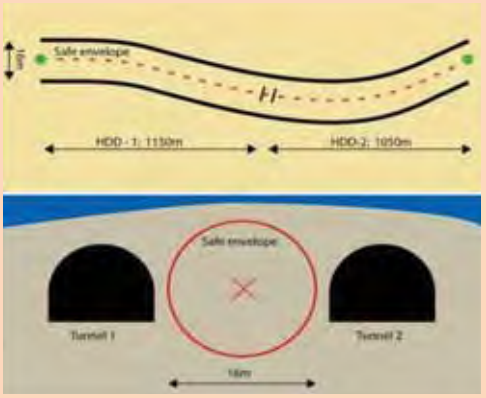
Strength and abrasion assessment

Information about rock quality is collected continuously along the route. The cores can be tested for mechanical and chemical properties including strength and abrasion, giving a better assessment of costs and production rates as well as reducing risks. This is particularly important for projects such as major tunnelling works, especially when using a TBM.

Use of the steerable directional coring technique reduces the number of drill holes, which in turn minimises the environmental impact and potentially the number of permits required. There is flexibility in terms of site access, as the ability to steer enables the hole to be started at the most suitable location. The holes may also be used to install instrumentation, such as settlement sensors, along the tunnel alignment.

The popularity of directional coring in Hong Kong is a consequence of the proven results of the technology. Intrafor's challenge is now to use the experience gained in Hong Kong to establish its path more widely across the world. ■

Key features of horizontal directional coring



Drill rig
A hydraulic drill rig provides the required power to drive the drill string over long distances at great depth.

Wireline drilling technique
In the wireline system, the outer tube of the core barrel and the drill rods are of the same size. The inner tube of the core barrel is inserted through the drill rods using gravity where possible,

with water-pumping used for horizontal or sub-horizontal inclined holes. After each core run, the inner tube and the rock cores are retrieved. An 'overshot' device catches the inner tube and pulls it back to ground level using a wireline hoist.

Electronic multi-shot hole profile survey instrument

This provides reliable survey data to ensure that drilling follows the required alignment.

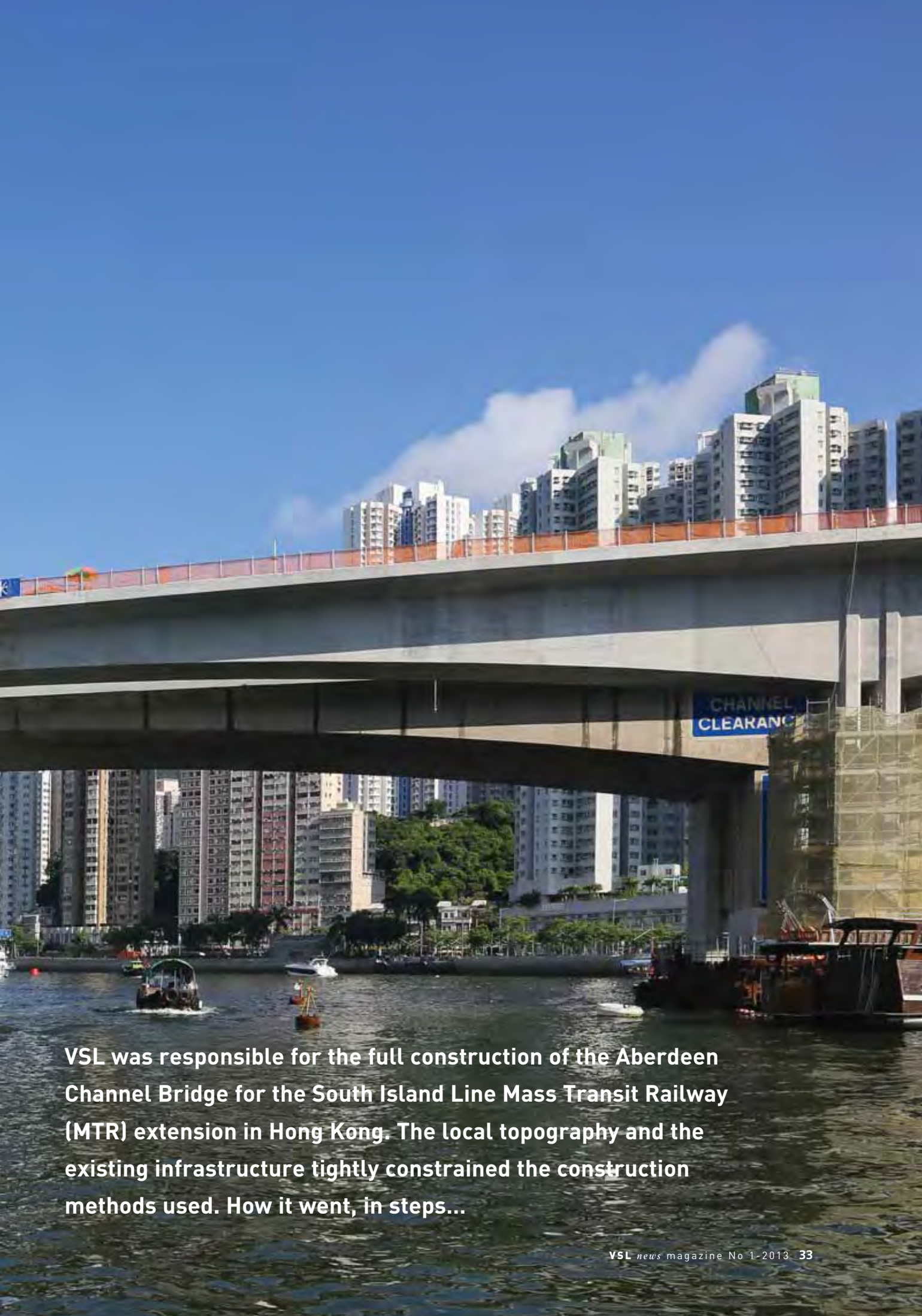
Steerable core barrel

Intrafor has developed a steerable core barrel system. The core barrel can recover rock cores while steering a hole along a predetermined trajectory. It is wireline operated and combines the advantages of a mud motor and a wireline core barrel. The key feature for accurate steering is the system's adjustable bent sub.

ABERDEEN CHANNEL BRIDGE

Full-scope construction

Aberdeen Channel Bridge will form part of the new South Island Line (East) of Hong Kong's Mass Transit Railway (MTR).



VSL was responsible for the full construction of the Aberdeen Channel Bridge for the South Island Line Mass Transit Railway (MTR) extension in Hong Kong. The local topography and the existing infrastructure tightly constrained the construction methods used. How it went, in steps...

tech show
BRIDGE CONSTRUCTION

1 Tackle site constraints

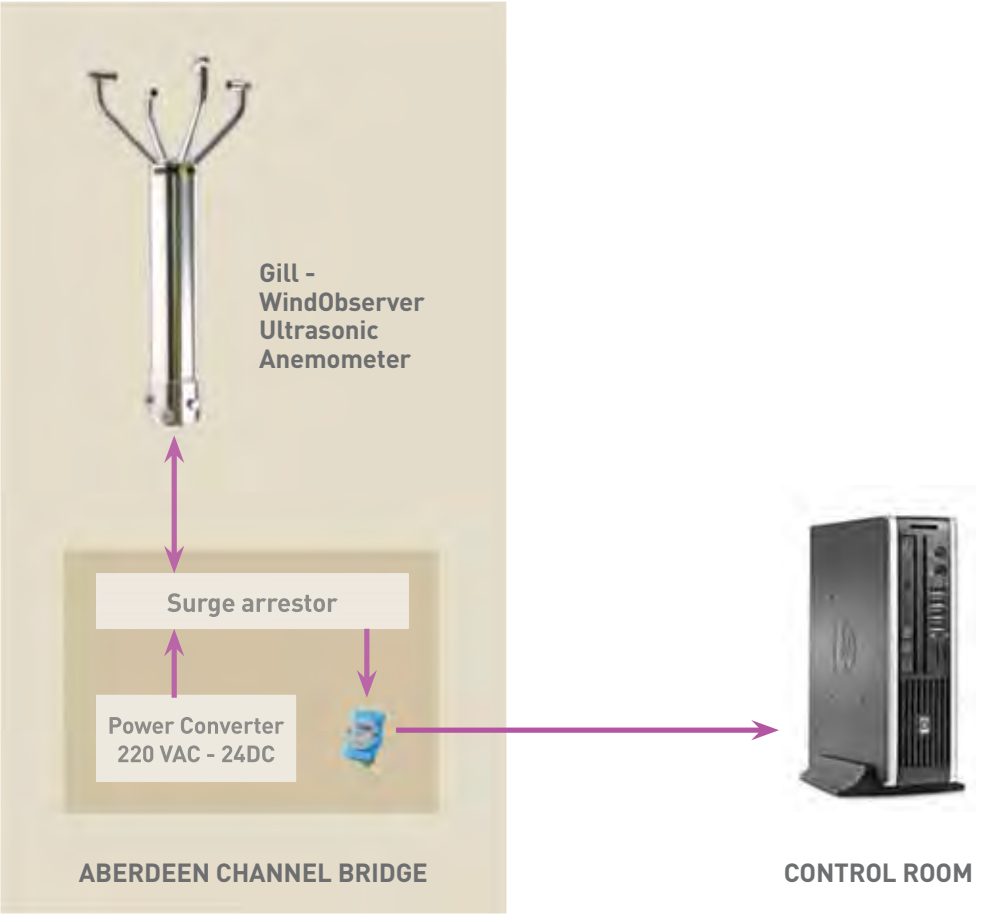
The 247m-long post-tensioned concrete box-girder bridge crosses the Aberdeen Channel linking a section of viaduct on Hong Kong Island to a tunnel on Ap Lei Chau Island. At the southern abutment, the bridge leads straight into a tunnel; at the northern end the deck rests on a short abutment shared with the viaduct. The two intermediate piers are aligned with the existing Ap Lei Chau Bridge piers to minimise disruption in the sea channel and also for aesthetic reasons.

2 Use EIT for long-term durability

The latest Hong Kong railway guidelines specify the use of airtight and watertight protective barriers for the post-tensioning steel. An electrically non-conductive, corrosion-resistant, durable material has to be used. Construction of the Aberdeen Channel Bridge marks the first application of these guidelines. Complete encapsulation of the post-tensioning steel is provided by the use of VSL PT PLUS® plastic ducts in combination with electrically isolated anchorages and high-quality vacuum-assisted grouting. This combined approach is considered a major step forward in achieving reliable long-term durability for post-tensioned structures. The electrical isolation was demonstrated on selected tendons after tendon stressing and both before and after grouting.

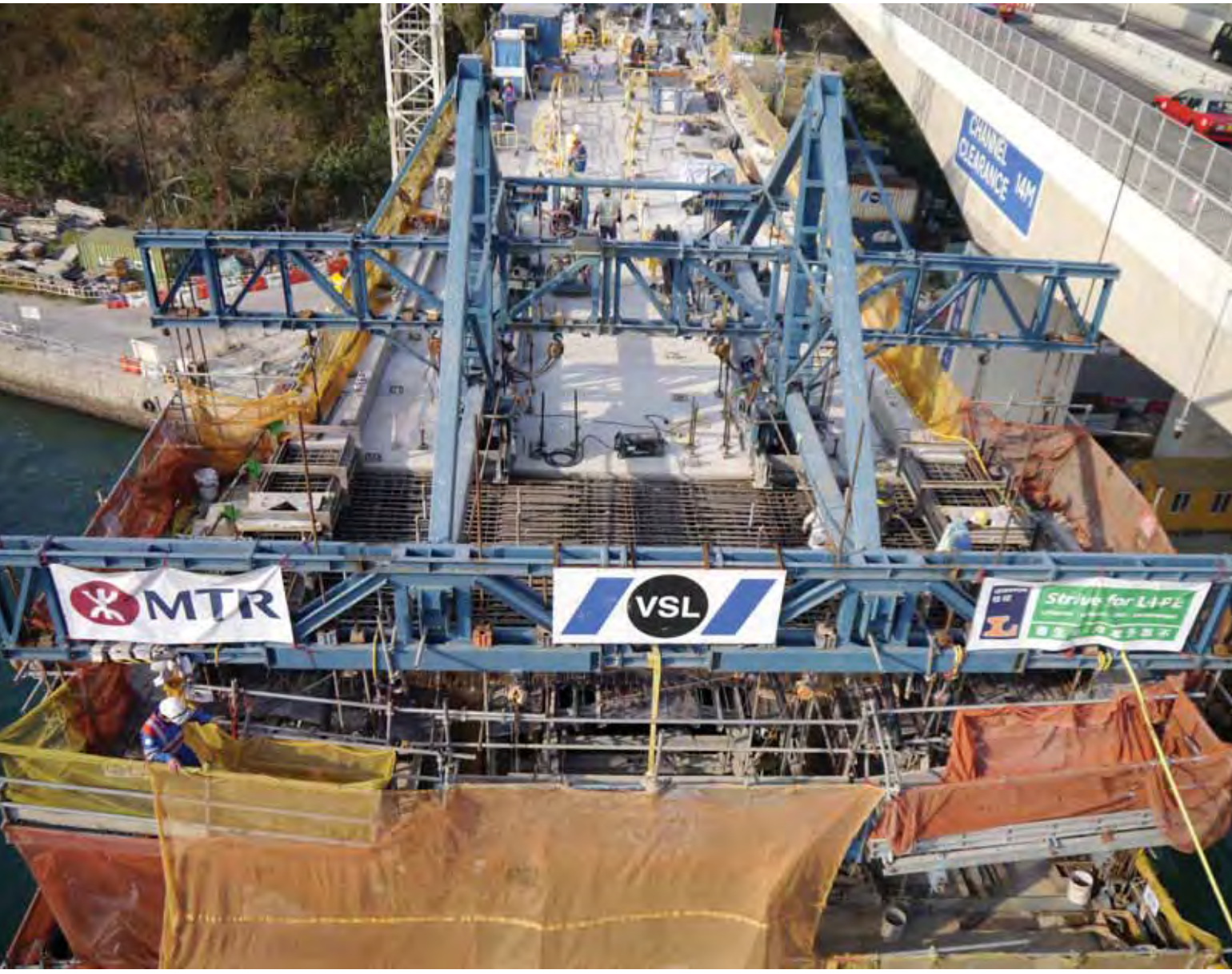
3 Increase protection with ICCP

An impressed-current cathodic protection (ICCP) system was chosen for the bridge's pile caps and piers. ICCP generates a current flow from the anode through the concrete to the steel and thus prevents electrochemical corrosion by forcing a current to flow in the concrete in the opposite direction to the corrosive current. In total, some 29,000m of anode ribbon have been used. The system has a design life of 120 years and, when installed during the construction phase, does not significantly increase the overall costs of the structure as it is relatively easy to install.



4 Fit a ship impact detection and wind speed monitoring system

VSL and FT Laboratories designed, supplied and installed a ship impact detection system. This system consists of six vibration sensors, which measure the displacement of the bridge and tracks in the event of a collision, and six day/night, high-resolution fixed colour cameras with IR illuminators. These cameras will be mounted at both piers of the bridge, pointing outwards into the navigation channel. The system can capture and record digitally information about any incidents such as collisions. An ultrasonic anemometer will be also supplied; it will be mounted in the centre of the bridge to determine wind speeds. Cables for monitoring and power supply systems have been installed in the piers, with junction boxes fitted into the hollow box-girder deck at the pier locations. Data from both the ship impact detection system and the wind speed monitoring will be collected and transmitted back to the control depot by just three fibre-optic cables.



5 Design, build and operate the form-traveller

Aberdeen Channel Bridge has three continuous spans, of lengths 58.5m, 115m and 73m, with the two intermediate piers aligned with those of the existing Ap Lei Chau Bridge. The new bridge provides a 70m-wide navigation channel and the main span is 14m above sea level. Two MTR tracks cross the 10.8m-wide bridge deck. A single-cell box section was selected as the deck is relatively narrow. In total, 54 segments were cast in-situ, with 51 of them erected by a modular form-traveller and the remaining three cast in-situ on falsework. The post-tensioned concrete box option was the most economical solution but was also the preferred choice as it harmonises with the existing bridge, which has a similar form.

6 **Install bearings and movement joints**
In addition, VSL supplies and installs 52 pot and 67 elastomeric bearings for the entire South Island Line 903 project, which includes segmental viaduct sections, station, depot and footbridge construction as well as waterway reconstruction. VSL also provides 250m of movement joints.

7 **Achieve high-quality while protecting the environment**
Aberdeen Channel Bridge is in a heavily populated area and full-enclosure noise barriers are to be provided to reduce the local impact. Building the bridge over the operating Aberdeen Channel made it essential to avoid disrupting the marine traffic below. A custom-made protective tray with a double-layer mesh was attached to the form-traveller's bottom form to catch falling materials and prevent any run-off of grey water. Achieving a high-quality concrete surface finish on the bridge was an important requirement and so a tailor made man-cage was designed for the finishing work on the main span surface over water, while a cherry-picker was used for the back span surface over land.

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