VSL news

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TECHNICAL CENTRES

GLOBAL EXPERTISE FOR LOCAL PROJECTS

Elevated segmental road bridges

Second Penang Bridge

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Cover photo: Second Penang Bridge

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Optimised solutions for complex projects

Daniel Rigout, Chairman and Chief Executive Officer

With its highly regarded experts in the Technical Centers, VSL can tackle even the most difficult of engineering challenges and provide what is really best for the project. Their technical expertise coupled with practical know-how allows them to provide advice and consultancy to both internal and external clients, optimising solutions in terms of constructability and the costs involved, no matter how complex the project.

The centralised teams of the technical centres support decentralised teams in 35 countries. They assist in finding alternatives when required and come up with new solutions wherever appropriate. Their excellent reputation, built on long-term experience, ensures invaluable support to the local teams when addressing complex projects requiring extensive preparation.

Such exchange of knowledge within VSL's global network enables the group's vast pool of experience to be fully exploited and applied across a wide variety of engineering fields.

Encouragement of lateral thought processes provides the ideal environment in which to nurture novel - and often remarkably simple - solutions to demanding problems.

This is how we like to serve our clients.

ENVIRONMENTAL PROTECTION

Sustainable construction

VSL, in a joint venture with China Harbour and Dragages Hong Kong, is building a 9.4km section of the Hong Kong-Zhuhai-Macao Bridge project. Environmental protection is at the heart of the work, which involves the design and construction of a viaduct over the deep waters to the west of Hong Kong.

Sustainability is high on the agenda for work on the Hong Kong-Zhuhai-Macao Bridge (HZMB) projects. All operations have to adhere to strict environmental policies regarding air, water and sediment quality, ecology, cultural heritage, waste management, noise and the impact on fisheries.

Reducing vehicle CO_2 emissions

The HZMB will provide the first direct road connection between Hong Kong, Zhuhai and Macao. The new route will help minimise CO_2 emissions from vehicles as it will significantly shorten journey times in the region. From Zhuhai to Kwai Chung Container Port, the distance and time will be reduced from today's 200km and 3.5 hours to about 65km and 75 minutes. Similarly, the journey between Zhuhai and Hong Kong International Airport will be cut from over 200km taking approximately four hours to about 40km and 45 minutes.

Protecting the Chinese White Dolphin

There are approximately 1,500 Chinese White Dolphins in the eastern part of the Pearl River Estuary and Hong Kong waters, with Hong Kong's highest density found in the waters west of Lantau Island.

The dolphins are protected and the 9.4km Hong Kong Link Road (HKLR) has been carefully aligned to avoid

the main areas where the species is found. In addition, extensive mitigation measures are being put in place to minimise the impact of construction.
There will be also constant observation for any sign of dolphins while work is taking place. Perimeter silt 'curtains' will be set up at a distance of 250m around the working areas to create a dolphin exclusion zone and operations will be suspended until any dolphin within the zone has left. All underwater percussive piling is banned and the formation of rock sockets for bored piles will be suspended from May to June, which is the peak calving season. Construction vessels are limited to a speed of 10 knots and must use designated navigation channels. The project will also adopt best practice measures that minimise sediment dispersal during dredging operations.

Minimising the environmental impact

Various alignment options for the link road were considered and extensive public consultation took place before Hong Kong's Administration decided to locate the boundary crossing facilities (HKBCF) northeast of the Airport Island. The HKLR will run along the Airport Channel at the southern side of the island, away from ecologically sensitive areas such as the San Tau Site of Special Scientific Interest, as well as seagrass and horseshoe crab nursery sites.

A tunnel-cum-at-grade road scheme was adopted in lieu of a viaduct option for the section from Scenic Hill on the Airport Island to the HKBCF to minimise visual impacts. The HZM Bridge being built by the Dragages-China Harbour-VSL Joint Venture will straddle the headland between San Shek Wan and Sha Lo Wan without affecting the natural shorelines of Lantau Island. Hydrodynamic impacts on the Airport Channel will be minimised by sinking the viaduct's pile caps to below seabed level in that section.

Comprehensive environmental monitoring

A comprehensive environmental monitoring and audit programme is being implemented during construction to check for any environmental impacts on the nearby sensitive areas that may be affected by work on the HZMB projects.
Perimeter silt curtains will be set up around all marine works to control spills and prevent sea-life entering work zones. Works will be suspended when dolphins are inside the 250m exclusion zone.
The monitoring and audit system will also confirm that protection measures are effective as predicted and identify areas for improvement. This will help to ensure that the project minimises environmental impacts while greatly enhancing the economic strength of the region. ■

RENEWABLE ENERGY

Solar power for geotech

FT Laboratories has introduced renewable energy options to power its range of equipment. Monitoring systems can now be fitted with solar arrays or wind turbines to provide power without installation of electrical supply. This option is

particularly useful for installing monitoring systems in remote areas or where an electrical supply is not readily available. It is also ideal for meeting client requirements for more environmentally friendly alternatives. ■

WORKING METHODS

VSL grouting in a bag

VSL Australia has recently added several bulk bag cement dispensers to its equipment pool. The dispensers were designed specifically to suit VSL's needs: they reduce manual handling, environmental impact and the risk of injury as well as improving quality and productivity. Cement is delivered in 1t bags, lifted by forklift or telehandler. Operation is 'push button' and the grout mixers can process 15t of cement per shift with just one operator, less dust and less wastage for both, cement and packaging, since the bags can be returned for reuse. ■

FSC COMPLIANCE

Forest-friendly formwork

Intrafor adopts reusable steel formwork as much as possible. However, it is still necessary to use wood for some applications, such as to cover starter bars in diaphragm wall panels. To reduce the environmental impact, Intrafor is now using 100% FSC-compliant wood, where available, for this purpose. The FSC (Forest Stewardship Council) identifies and certifies forests that are well managed and where biodiversity, productivity and the ecology are maintained. ■

AND THE WINNER IS...

Newmarket viaduct again!

The Newmarket viaduct replacement project has won several more awards. It was successful at the Association of Consulting Engineers NZ's 2013 awards, winning the Gold Award of Excellence, and the input of design partners Beca, T&T, URS NZ and Boffa Miskell was also recognised. Further success came at the New Zealand Contractors' Federation annual awards. To cap it all, the Northern Gateway Alliance (NGA) - responsible for delivering the project - won the 2013 Roading Excellence Supreme Award and the NZ Concrete Industry Award in November. ■

AWARD

Best subcontractor

The high quality of VSL's project management on Qatar's Lusail project led to Samsung C&T naming it Best Subcontractor in June 2013. The new city is one of the most ambitious projects being undertaken as part of the Qatar 2030 vision. VSL was awarded post-tensioning works for the project's bridges, which connect five artificial islands to each other and the mainland. Two are iconic suspension bridges that feature steel rings serving as 50m-tall pylons that represent the 'Q' of Qatar. ■

SAFETY DAY 2013

Fire safety

VSL Thailand's latest annual safety day focused on fire safety. It was run with the assistance of Thailand's National Fire Service Training Team, which usually trains firefighters. Practical exercises covered fire prevention, fire drills, oil and gas handling and small-scale fire-fighting. Fire safety is particularly important in Thailand due to the widespread use of bottled gas and the use of wood in building houses and temporary structures. ■

facts & trends

First for Bosnia
Twin viaduct launch

→ **Pavlovići Viaduct on Pan-European Corridor Vc** has become VSL's first contract in Bosnia & Herzegovina. The 385m-long multi-span concrete twin viaduct near the Croatian border has typical spans of 43m. The incremental launching method (ILM) is used to erect the single box girders, which are prestressed with internal tendons. VSL's client is OHL, which is building the bridge to a design by IPSA. VSL's work includes providing the ILM technology, the post-tensioning system and permanent bearings. ■ Contact: pvanek@vsl.cz

Infrastructure protection
Police shield

→ **VSL Infrastructure Protection has recently secured a contract to provide blast engineering analysis and design services** for the glass façade of the new City West Police Complex being built in Melbourne, Victoria. The blast engineering requirements for the 'super complex' are extremely stringent. The project's fully glazed curtain wall facade has over 20 different configurations, all of which require complex analysis to ensure they meet the performance specifications to limit deformation and prevent airblast affecting the interior of the building. VSL IP is working closely with façade contractor G James to engineer the optimal design solution for the main contractor. ■ Contact: gavin.wight@vsl-ip.com

AF Anchorage on LNG tanks
Island firsts

→ **LNG projects on Curtis Island and in Darwin are the first in Australia to use VSL's AF Anchorage.** VSL is involved in prestressing of 6 LNG tanks for three facilities being built on Curtis Island and 4 LNG tanks in Darwin for processing of network gas. On the two projects, AF anchorages as 'blind dead end' terminations of the vertical tendons are used in lieu of conventional 'U' tubes. The new anchorages improve structural detailing and construction efficiency. ■ Contact: david.trayner@vsl.com

New territory
Onward into Ontario

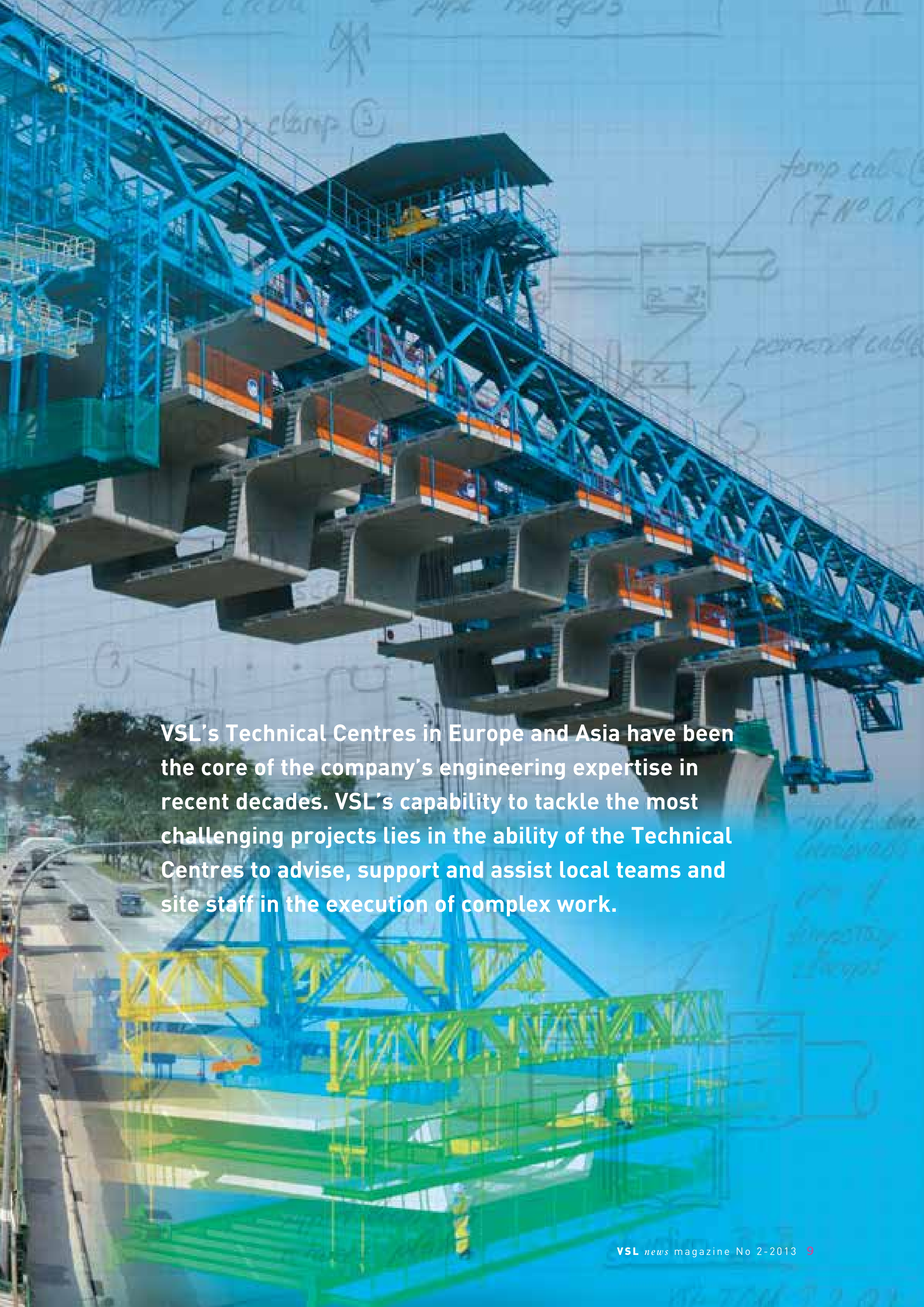
→ **CTT-Stronghold Canada has completed its first project in Ontario.** CTT's contract involved the supply and installation of 500t of post-tensioning for six concrete box girder bridges as part of the Rt Hon Herb Gray Parkway (formerly the Windsor-Essex Parkway). The Parkway is a major $1.4 billion highway infrastructure project, which, once completed, will be an essential part of Canada's premier trade gateway. ■ Contact: jose.menchaca@vsl.com

Corporate identity
New look and feel

→ **In the past years, Intrafor has developed to become a leading ground engineering specialist** with emphasis on products and solutions with high technical content. The division had outgrown the old corporate identity, which was implemented more than 20 years ago. By introducing a new corporate identity Intrafor is improving the visibility of its brand, giving a modern, yet classic and dynamic image. ■

TECHNICAL CENTRES

Global expertise for local projects



VSL's Technical Centres in Europe and Asia have been the core of the company's engineering expertise in recent decades. VSL's capability to tackle the most challenging projects lies in the ability of the Technical Centres to advise, support and assist local teams and site staff in the execution of complex work.

VSL's activities demand a high degree of expertise and know-how in all fields of civil engineering and specialised bridge construction. This highly skilled and specialist activity requires staff with an in-depth knowledge of VSL's systems and technologies. While the 50 VSL bases around the world certainly have the ability to handle most of their clients' projects, they can also rely on their colleagues from the Technical Centres in Asia and Europe for assistance with major or special projects and engineering tasks going beyond their normal day to day activities.

"Of course, a team of bright thinkers creates a pool of energy."

A core team is on hand, made up of structural and mechanical engineers, method engineers and experts in particularly specialised activities, such as stay cables, VSoL® or construction equipment. On demand, they assist the local teams and their clients in finding the best solution, looking at alternatives and seeking opportunities to identify what is best for a project and to help move it in the right direction. The client can be confident that the expertise of the Technical Centres is available, if need be, at every phase of the project, right from the start.

A specialised team of engineers for specialist construction

Technical Centre's engineers (TC engineers) define construction, specify the equipment and the installation on site and carefully check interfaces with permanent work. They also develop the schedule for the construction of projects, establishing the materials and human resources required, carry out the design of specific equipment (such as formwork or safety equipment) and supervise their fabrication. TC engineers are there at the start of construction to finalise the methods that will be used on site.

TC engineers take also an active part in the design and optimisation of structures to allow use of VSL systems and construction methods and propose alternatives to simplify construction and make best use of materials.

Engineers from the Technical Centre in Singapore are not only responsible for all the equipment used on special projects designed by the Technical Centres, but is also developing equipment for the installation of post-tensioned cables. The team has designed a new generation of multistrand stressing jacks and is presently carrying out further development of a range of tailor-made equipment needed for the installation and stressing of prestressing cables for use in nuclear power plants in Korea, France and Russia.

"We are a service provider to all our clients, internal or external," sums up a senior engineer. *"We know how to design a project and how to build it. We can estimate how engineering will affect the production process. The engineers in the technical centre have an in-depth knowledge of site interactions. Combined with their site experience, they are an invaluable consultant for the designer and the client."*

At the same time, the centres are a great training place for young engineers starting in the group. Here, junior engineers are trained by senior staff members, who transfer their knowledge and best practices to the new arrivals. Armed with their new expertise, the young engineers can provide invaluable support to their local teams as they

"We do not outsource - we do it all ourselves."

Contributing to smooth project execution

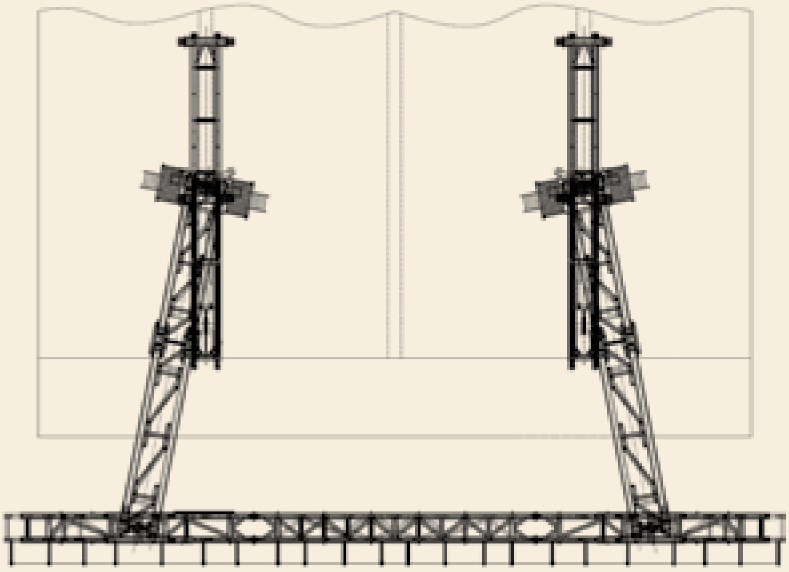
Assistance from VSL's Technical Centre in Switzerland is contributing to the successful construction of a three-span cable-stayed bridge in the USA. Early input into the construction methods helped save money and time as well as making the work safer. The **Ironton-Russell Bridge** is owned by the Ohio Department of Transportation (ODOT) and links the city of Russell, Kentucky with Ironton, Ohio. The US$81.3 million project, which started in March 2012, is due to be completed by 2017.

The side spans are being built on specially designed falsework simultaneously with construction of the pylon to create land access for the installation of a form-traveller and erection of the 275m main span. VSL is supplying the 130t form-traveller. In joint venture with its US partner VStructural, VSL is also providing 125t of post-tensioning in addition to the supply and installation of 305t of the VSL Stay Cables. The bridge's main span consists of 30 segments each supported by two stay cables ranging from 14 to 33 strands. Each segment weighs about 180t with a length of 8.9m and a width of 13.8m. The scope of work carried out by the Technical Centre in Europe (TCE) includes:

Design of the form-traveller, issuing engineering drawings and a fully detailed 3D model built using SolidWorks®, checking of the shop drawings issued by the steel fabricator, production of an operational manual including construction methods and assembly kinematics, supervision during fabrication, load testing and trial assembly of the form-traveller.

The underslung form-traveller was manufactured in April 2012. It was delivered to site in May 2013. Building the bridge requires the installation and partial stressing of the stays before casting the concrete to prevent excessive bending in the deck. After concreting, a second re-stressing operation is performed on the stay in order to absorb the deck's deflection before launching the form-traveller to the next segment.

VSL proposed the innovative use of precast stay anchor blocks, in order to eliminate the complex stay details required to transfer the stay force from the form-traveller to the structure, and to reduce the construction cycle time. Precasting the stay anchorage blocks with this variable geometry and place them directly in the form-traveller, omits need for temporary fixity of the stay anchorages to the traveller, which is technically complex. The two hydraulic systems developed for use on the project enable independent control of the form traveller's structural frame and its formwork. This contributes to a significant weight reduction in the telescopic parts. This project is challenging due to strong interaction between equipment design and stay cable construction engineering, which has required close collaboration between the bridge designer and the VSL design team. Erection of the form-traveller on the bridge is due by the end of 2014.



For the form traveller of the Gateway upgrade project, TCA suggested that the frames were splayed on plan. The rear reaction to the deck remains directly over the webs.

The form-traveller design provided excellent access to all the required working areas and allowed placing of prefabricated web reinforcement.

Innovative form-traveller design

VSL's Technical Centre Asia developed an innovative form-traveller design that made an important contribution to the successful completion of the **Gateway Upgrade Project in Brisbane,** Australia. The design allowed prefabricated web reinforcement to be lowered into place, saving time while ensuring that the operation could be carried out safely. VSL's Technical Centre Asia was involved in the project from an early stage, helping to define the construction methods and influencing the design of the bridge's permanent works by providing advice on constructability issues.
The New Gateway Bridge has an overall length of 1,627m including a 260m main span, which is one of the world's longest concrete bridge spans unsupported by stay cables. The main span deck consists of a twin-cell box-girder, cast in-situ using the VSL form-traveller to produce segment lengths of 3m, 4m and 5m. The heaviest segment cast using the form-traveller was 386t. The depth of the 29.35m-wide deck at the main-span piers is almost 16m. In order to place web reinforcement steel quickly and safely, it needed to be prefabricated and lowered into the web formwork.
However, traditional form-traveller designs have the main frames parallel with the bridge so that the loads are applied to the webs of the deck. This does not allow lowering of prefabricated web reinforcement cages into the formwork. TCA therefore suggested an innovative approach that allowed the frames for the form-traveller to be splayed in plan. The rear reaction to the deck remained directly over the webs and, close to the leading edge, a transverse beam supported the frames

tackle challenging projects.
"It is interesting to work on several projects at a time - this is very rewarding," comments an engineer. *"Every project has an aspect that gives you satisfaction," "We communicate with the designers, because we can advise on how to design a construction-friendly bridge. We offer the best solution."* Consultants do appreciate.
The solutions that are devised are

and transferred the reactions across to the webs. This allowed sufficient space for the prefabricated web reinforcement cages to be lowered directly into the formwork. The design provided excellent access to all the working areas and could accommodate the full depth variation of the deck from 15.7m to 5.2m along the cantilevers. As a result, the site team managed to achieve a segment construction cycle time of three days. This contributed to a significant reduction in the construction time of the main spans.

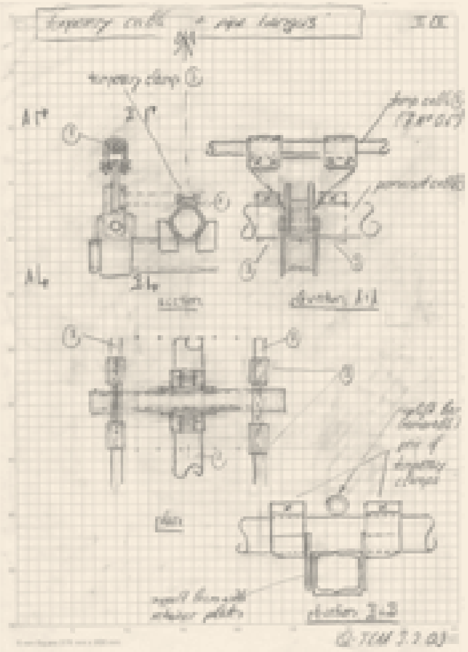
The basis of the design was the standard modular form-traveller used extensively throughout the world but with significant modifications for the project. Designers from the VSL's Technical Centre Asia spent time with the site teams to ensure that the design catered not only for physical project-specific constraints but also addressed other factors, such as the high labour costs and extremely high safety expectations commonly encountered in Australia.

Understanding of the fabrication processes and awareness of the progress allowed VSL's Technical Centre Asia to optimise design changes to minimise disruption to the schedule. VSL's designers also assisted with the assembly and commissioning of the travellers on site. During construction, they then provided support to ensure the smooth-running of the equipment and to design any enhancements or additional features requested by the site teams. Technical Centre Asia's involvement continued to the end of the construction, in designing the adaptation of the traveller frames for use as deck-stitching beams and in developing the heavy-lifting methods used for the lowering of the formwork.

very often technically one of a kind, not merely re-using what already exists but developing and innovating to design what is best for a project. The teams give support from the beginning to the end of a project, and

Cost-effective solution for a suspension bridge

Another technical milestone for VSL was the design and construction of the **Subansiri Suspension Bridge**, where the adoption of innovative solutions enabled the costs and complexity of construction to be greatly reduced. The suspension bridge over the Subansiri River has been built to support a conveyor belt used to carry aggregates for construction of a dam. VSL's scope of works was, apart from the design of the bridge, to supply the bridge's main and hanger cables as well as to erect the main cables and the deck. This specialist work was carried out in collaboration with the Technical Centre Asia, which undertook the design and detailing together with the construction engineering for the whole bridge. In addition, a TCA engineer and superintendent were seconded to the project.



Visualize ideas before the computers are switched on.

Construction of river piers was considered by the main contractor to be impractical and unsafe as the flow in the Subansiri River triples during the rainy season. This meant that the bridge had to span 300m. TCA proposed a suspension bridge that was structurally similar to the Mamberamo Bridge, which VSL Indonesia had previously worked on. Such suspension bridges have two pairs of main cables. The hanger cables that support the deck are only suspended from one pair of main cables, switching between the two pairs at the centre of the main span. This means that each main cable runs straight over half of the main span length, improving aerodynamic stability. Technical Centre Asia produced all shop drawings and was responsible for development of the methods for assembling and installing the main cables and erecting the deck.

The solutions developed by VSL's Technical Centre demonstrated how the costs of building a suspension bridge can be minimised by using parallel galvanized strand bundles as main cables. In addition, the method of erecting the main cables avoided the need to install a cable way. The approach exploited also the fact that the river is navigable, allowing the bridge deck to be preassembled into modules on land, delivered by barge to site and lifted along the hanger cables into position.

Main cables that are 515m long and made up of 30 strands pass over saddles on top of steel pylons reaching 35.9m high above deck level. The hanger cables are suspended at 9m intervals from the pairs of main cables. To avoid using a temporary pontoon bridge which could be flooded, the VSL solution was to establish a straight assembly bed along the river bank and a launching track on the island side, and to use fixed rollers to support the main cables. The main cable was pulled over the roller supports by a winch until the front end reached the pylon.

For crossing the river, a pair of temporary suspension cables was installed next to the pylon leg. The main cable was suspended from the temporary cable by special hangers and then pulled over the river. Saddles were installed at ground level and the cable was lifted simultaneously on both pylons using strand lifting units. After all four main cables had been installed, the 16m- to 20m-long deck modules were transported on barges to the lifting points. Four SLUs used the hanger cables to lift each module to the desired level. The final operation was to install the conveyer belt itself.

Tackling unusual design requirements: Distrito 38 – Spain

An alternative design from VSL has helped improve the layout of a complex office building at the heart of a new business zone in Barcelona: **Distrito 38**. Switching from structural steel to post-tensioned concrete has allowed the creation of large cantilevered slabs and open column-free spaces. It was important in this project to develop structures with a flexible layout that allows for later rearrangement as new and developing requirements emerge.

The site faces part of the Paseo de Zona Franca, a key thoroughfare in the district. Using this as an anchor, a 7.5 x 7.5m grid has been defined as the basis for the layout of six planned buildings and their parking areas. Arata Isozaki's D38 offices development is probably one of the most challenging buildings built in Barcelona in the last years. The building has a distinctive appearance, with open 'missing' sections on each level and cantilevered floors above. The sides measure 52.5m x 52.5m and the building has a height of 46.5m. The overall shape is almost a cube with a central concrete core and the offices arranged like a 'square doughnut' around it. A peculiarity of the building is that all the floor slabs are different: only one or two cover the full area, the others have cut-outs to make them C-shaped or L-shaped. This allows the interior of each to be organised into one, two or three units. Further complications come as the C and L-shapes on different floors rotate around the core. Originally, the floors were arranged with a matrix of columns spaced on a 7.5m by 15m grid. As a result, the original, conforming solution was planned as a steel structure with extensive use of tension members to hang parts of the slab from the floor above. Some columns stood on a beam, there was no continuity in the columns and it would have been very complicated to build the building. In essence, VSL's proposal was to change from steel to concrete and then to make every single slab independent from the others by means of post-tensioning. VSL also removed all internal columns and some of the external so that the 'doughnut' was left completely free for office space. The design created huge cantilevers and more than 50% of all the building's columns were removed. The building includes slabs with clear spans of 15m by 30 and 45m, with cantilevers of 7.5 and 15m, solved with a combination of waffled and ribbed post-tensioned slabs together with post-tensioned edge beams. It was clear that the solution was ideal and so VSL proposed it to the main contractor, which put it forward to the architect and consultant. VSL was asked to produce the final solution and the Architect was so happy with the proposal that one of the associated architects was brought over from Japan to fine tune the final column layout with VSL. All parties were very pleased with the result as it improved the building's layout and saved both money and time.

> *"Being constantly on a learning path means nothing is stagnant; all problems are overcome at the end."*

log the feedback from one project to the next. The Technical Centres thus become a design hub for the VSL network, producing documents – drawings as well as fabrication and operational manuals – that will become the standard for future projects.

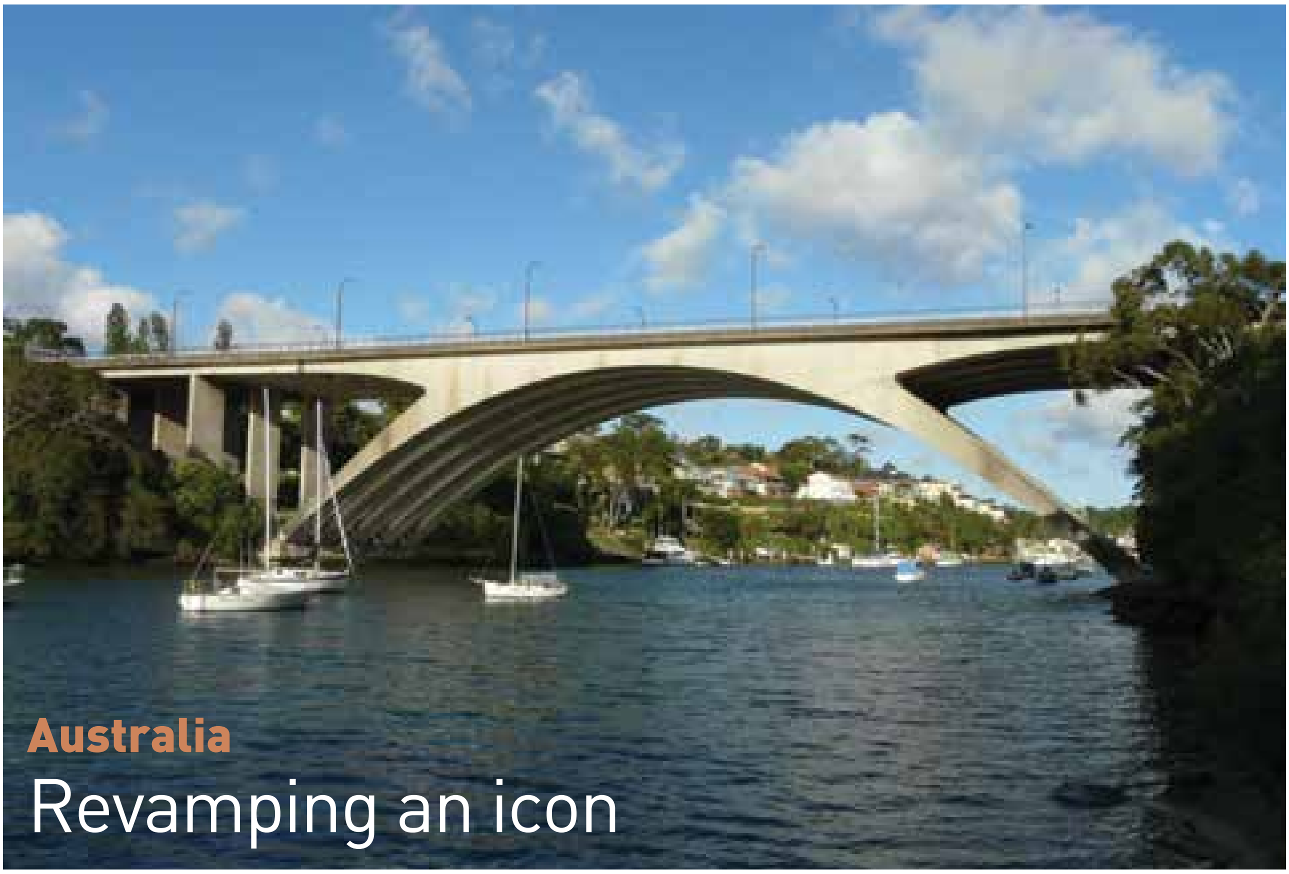
Constructable and efficient

Teams from the Technical Centres are involved from the very beginning, starting with a technical SWOT analysis, through to providing the tender teams with drawings and images for a better understanding of the project and helping produce the associated bills of quantities. *"We propose alternatives, new solutions,"* is how a stay-cable specialist puts it. *"We want to do a technically sound job, but also to contribute to the aesthetics of these landmark projects. A cable-stayed bridge has to integrate well into the landscape. Its design and architecture are important for the project's success."*

Stay-cable projects are a good example as evolutions and developments in recent years have contributed to improvements not only in the life and structural behaviour of bridges but also their aesthetics. The VSL Saddle, the SSI 2000 Compact System and various damping solutions are just a few of the key developments. Every project is considered unique, demanding bespoke solutions but without taking careless risks. *"Our clients' requirements challenge our capacity to innovate, to find new solutions,"* observes an engineer. Once a project has been secured, the Technical Centre becomes a communication and information point for the designer, while supporting the client. During project execution, the teams on site will receive all the necessary support for installing and operating the systems, closely followed by specialist input from the Technical Centre to ensure quality control.

The teams from the Technical Centres in Singapore, Thailand, India, Switzerland and Spain enable their local colleagues to get on with the job without getting lost in the details. They train, listen to and learn from others. *"I found my dream job without knowing that it existed,"* says a member of the Singapore team. *"You arrive and bring your former work experience with you and use it to make things happen within a dynamic team of experts."* Every new project brings new challenges to tackle, so too do VSL's newer business lines such as wind turbine erection and offshore applications. Striving to be a genuine service provider is the key. ■

> *"This is the real driving force - there are always new challenges. You can never say you've seen it all."*



Australia
Revamping an icon

→ **Rehabilitation of the iconic Tarban Creek Bridge** is being carried out by VSL under a contract awarded by Roads & Maritime Services of New South Wales (RMS). Giving the 38-year-old arch structure a new lease of life involves provision of two new supports of the bridge deck by construction of two portal structures, which are 18m high and 35m long, and replacement of the bridge's concrete diaphragms with steel cross girders. A key feature will be the construction of the portal's massive post-tensioned beams. VSL's Technical Centre designed a temporary steel falsework platform that will be preassembled on ground together with reinforcement and formwork and slid and lifted into casting position by using sliding and heavy lifting techniques. ■ **Contact: david.trayner@vsl.com**

Taiwan
Higher deck

→ **The low deck of the old Hua Zong Bridge caused problems** at times of flooding and so a new designed structure was raised by 3m. The 147m-long bridge on the Jiang Jun River is on a major route in Tainan's Xue Jia district but use of a 'half and half' construction method has kept traffic flowing. VSL is supplying and installing its SSI 2000 Stay cable system for the hangers of the 16m-wide, three-arch steel structure. ■ **Contact: Johnson.chang@vsl.com**

Courtesy of Public works Department of Republic of Indonesia

Indonesia

Nine turns

→ **Kelok 9 is a unique name of an elevated road** consisting of nine turns and stretching over 2.5 km in length. Officially opened on 31st October 2013, the road which was financed by the central government was built to solve the bottle neck of highway between Bukittinggi in West Sumatra Province and Pekanbaru in Riau Province. The width and gradient of road was significantly improved in order to minimise traffic congestion. VSL's scope of works included post-tensioning and engineering of a section which is composed of a cast in situ balanced cantilever bridge. ■ **Contact: Jootje.massie@vsl.com**

Vietnam

Elevated segments

→ **Precast segment work will be carried out by VSL** as a specialist subcontractor JV team on an elevated section of the Ho Chi Minh City's new Metro Line 1. Most of the 19.7km route is elevated, running on viaduct for 17.3km as it passes through 11 of the line's 14 stations. VSL is working on the Ben Thanh Market to Suoi Tien Park section. The city's Management Authority for Urban Railways is developing Line 1 as a new spine for the public transport system. It is expected to carry more than 160,000 passengers daily in its first year, increasing to 635,000 by 2030. ■ **Contact: lan.tranduc@vsl.com**

Vietnam

Bank HQ

→ **VSL Vietnam will complete its post-tensioning work** at the new city headquarters of Vietcombank in Ho Chi Minh City in December 2013. The Vietcombank Tower project has involved the supply and installation of 200t of strand for post-tensioned slabs and beams in the 35-storey office building. The tower also has a four-level basement and areas for services, retail, restaurants and parking. Vietcombank is one of the country's largest local commercial banks and the new building's 3,200m² site is right in the centre of the downtown area. ■ **Contact: lan.tranduc@vsl.com**

Taiwan

Controlling structural behavior

→ **The Central Garden Building project is a residential scheme** located in the Qian-Jin District of Kaohsiung City, Taiwan. The building has a height of 37 storeys and a seven-storey basement. A total of 36 sets of VSL dampers will be installed from the 11th floor up to the 19th. The wall-type dampers are 1.35m high and use one viscoelastic damper unit per set. They are integrated into prefabricated steel panels that are installed directly in the structure during construction. Installation of the VSL damper systems started in June 2013 and will be completed in 2015. ■ **Contact: Johnson.chang@vsl.com**

Taiwan
Designed for typhoons

→ **Typhoon Morakot destroyed the old Shan Mei Bridge** in the Tanaiku National Park and so the replacement structure has been designed to ensure integrity even when torrents come rushing down from the mountains. The new design has a 115m-long single steel arch fitted with the VSL SSI 2000 stay cable system for the hangers featuring the latest developments in anchorage technology and corrosion protection systems. VSL is supplying and installing 20 sets of 6-31 anchorages, 1,000m of galvanised strand and 350m of HDPE pipes. ■ **Contact: Johnson.chang@vsl.com**

Taiwan
Freeway travellers

→ **Two pairs of VSL form-travellers have recently begun construction** of a bridge on National Freeway No 8. The structure has a double-box bridge deck with spans ranging in length from 65.57m to 110m and girder depths of between 2.8m and 5.65m. The bridge superstructure is being built by the cast-in-situ segmental balanced cantilever method, so the symmetrical segments of the 20m-wide deck are constructed on both sides of the piers. The VSL form-travellers are of a modular design that enables the truss and the width of the bottom slab to be adjusted to suit the bridge cross-section. ■ **Contact: Johnson.chang@vsl.com**

Australia
Safer crossing

→ **In order to replace a level crossing with an overpass,** VSL was recently awarded the design and supply of 3,925m² of VSoL® Retained Earth Walls. The VSoL® walls will stand up to 11.7m high and be faced with 2m by 2m plain grey panels. The retained earth walls are an integral part of the Robinson Road project, which is designed to remove a bottleneck and deliver a safer and more efficient transport network by the construction of a road overpass crossing the rail line. ■ Contact: steve.mills@vsl.com

Australia
Terminal slab

→ **VSL has been awarded a contract** to design, supply and install post-tensioning and associated slab reinforcement at the Patrick Terminal in Port Botany. The 45,000m² of post-tensioned pavement is part of a container terminal expansion programme for a major logistics company. Use of a post-tensioned slab was adopted by the client as it offered excellent abrasion resistance against the braking and turning stresses imposed by the terminal's automated straddle cranes. The dramatic reduction of joints improves slab robustness and also minimises the risk of pavement 'rutting'. ■ Contact: chan.cheong@vsl.com

Hong Kong
Very low headroom

→ **Leighton awarded Intrafor a contract for a MTR interchange station,** part of the new 17 km long Sha Tin to Central Link metro line project. Located under the podium structure of the existing Hung Hom station, the works comprise 1075lm of 1.2m thick diaphragm wall and barrettes ranging from 20m to 60m in depth, representing a total of 40,000m³ of excavation. 5 slurry walls totaling another 3,400m³ of excavation are also part of Intrafor's scope. The main challenge is to work under a very low headroom of 5.5m. Excavation is carried out using mini-cutters and special low-headroom grabs with boom and grab length reduced to the minimum. Cranes had to be modified and a special gantry system had to be developed to move equipment and reinforcement cages. ■ Contact: guillaume lamoitier@vsl-intrafor.com

Poland

Two for Torun

→ **VSL has recently completed missions on two bridges** in the city of Torun in northern Poland. The highly curved Zolkiewski Estakada Viaduct, which opened in August, is supported by stay cables installed by VSL Polska.

Work took place simultaneously at a nearby 265m-long arch bridge over the Vistula River with two spans, where VSL carried out a three-month operation to lift 16 deck segments. In the first phase, the segments – weighing up to 250t - were lifted 15m from a pontoon and suspended from temporary hangers. They were aligned in a second operation before the loads were transferred to permanent hangers. ■ **Contact: m.targowski@vsl.com**

Czech Republic

EIT for Troya Bridge

→ **Construction of the Troya Bridge is nearing completion.** VSL supplied both longitudinal and transverse electrically isolated tendons (EIT) for cast-in-place beams and slabs. Tendons ranged from the four-strand bonded slab system to the multistrand CS Super 6-37. The bridge, which has a 200.4m-long steel arch main span, crosses the Vltava River. Metrostav divisions 2 and 5 are building the bridge on behalf of the City of Prague to a design by Mott MacDonald Praha with construction analysis by Novák & Partner. ■ **Contact: psmisek@vsl.cz**

Turkmenistan

Beams at Ashgabat

→ **Following on from the heavy lifting works,** VSL has now been appointed for the design, supply and supervision of post-tensioning for the beams at the Ashgabat's Congress Centre in Turkmenistan. Bouygues Turkmen is building the centre, which features beams that span between 40m and 45m and incorporate VSL's GC6-12 and GC6-19 anchorages. VSL is due to supply the post-tensioning materials and equipment by the end of 2013 and will then supervise the post-tensioning activities in early 2014. ■ Contact: antoine.samaha@vsl.com

Qatar

Work in progress

→ **After successfully completing the original cut-off wall scope of 52,500m²** over a plan length of 3,150m on the New Port Project in Qatar, VSL-Intrafor were awarded additional works comprising the construction of an additional 55,530m² of cut-off wall over a plan length of 3,210m, including geotechnical investigation works and providing specialist plastic concrete. The cut-off wall is being constructed using VSL-Intrafor's BC40 Cutter equipment and a special plastic concrete mix; excavation works for the wall are being carried out to depths of up to 22m below existing ground level. The cut-off wall reduces the horizontal flow of water through the subsoil and fractured limestone, facilitating the safe and economical dewatering and dry bulk excavation works in the port's access channel. ■ Contact: keith.ryan@vsl-intrafor.com

Russia

Repeat success

→ **A well adapted solution has enabled VSL to secure the contract** to supply the stay cable system for the Novosibirsk Arch Bridge in Russia. VSL's remarkable concept allows the bridge's 156 stays to be lifted without using any type of platform at arch level. The concept includes prefabrication and lifting of complete stays, which reduces the time needed for erection from three months to two. VSL is also providing equipment and supervises the stay installation by contractor Sibmost. The bridge's designer, Stroyproject, has already worked with VSL on a number of Russian projects. ■ Contact: Julien.violle@vsl.com

NOTE PAD

Toughened tunnel. The latest scheme in the development of Dubai International Airport is the strengthening of the 1.5km Beirut tunnel running under the airport. VSL won the contract to install 280t of post-tensioning to improve the load-carrying capacity of specific areas of the tunnel roof. The strengthened roof will allow the area above to be used as aircraft stands for future airshows.

Jumana Island access. A new man-made island is currently being developed in the heart of Dubai's beachfront shoreline of Jumeirah. VSL is providing its 6-19 and 6-12 post-tensioning for use on the 502m-long nine-span bridge that will connect Jumana Island to the Jumeirah coastline. The bridge is set to be completed in February 2014.

Stays, pipes and dampers. A consortium led by Viadukt has contracted VSL to supply and install the stays for the Drava Bridge in Croatia. The bridge, designed by the Croatian Institution of Civil Engineers (IGH), is a suspended composite steel bridge with a 420m main span over the river, flanked by semi-prefabricated concrete structures. VSL's work includes the engineering and supply of the stay-cable system's 470t of strand, 80 sets of anchorages, HDPE pipes and friction dampers. VSL will also be providing equipment and supervising the installation.

Bridge upgrade. VSL is supplying and installing strand, anchorages and bars for the strengthening of the Wan Da Bridge in Taiwan. The 735m-long crossing of the Kaoping River stands on 22 piers and requires the installation of 450t of 15.2mm-diameter strand, 16,800m of galvanised steel ducts, more than 500 sets of E6-22F and E6-27F anchorages and 1,250 PT bars.

France
Repeat hangar

→ **The first section of the steel roof structure** for the latest Airbus hangar in Toulouse, France was raised by VSL in June. The roof consists of two parts, weighing 970t and 770t. A single operation raised the first section by 24m using 10 lifting points. VSL had already performed the roof lifts for the two previous Airbus hangars in Toulouse. ■ Contact: marc.winkelmann@vsl.com

Switzerland
Sliding box

→ **A new underpass is being built in Rickenbach** to allow pedestrians and cyclists to cross under the railway. VSL slid the 280t concrete box, fabricated on site, into its final position underneath a temporary railway bridge while the line was still in operation. The box was pulled more than 20m at a maximum speed of 10m/hour on a slide system, closely guided to ensure a smooth operation. ■ Contact: robert.monger@vsl.com

Switzerland
Alpine achievement

→ **Stringent requirements had to be met in work** for two rail bridge packages in Camorino as part of the Alptransit Gotthard project. VSL won the contract to supply and install prestressing tendons, which are electrically isolated for protection against stray currents and corrosion. Limited space within the bridge cross-sections meant that special deflection elements had to be constructed. Meeting the client's deadlines while achieving the stringent quality requirements demonstrated the efficiency of the VSL system and the expertise of the site personnel. ■ Contact: hannes.mueller@vsl.com

Switzerland

Secured with anchors

→ **Extension of Switzerland's A16 highway in Court** in the north-western part of the country includes construction of several tunnels and bridges. More than 4,000 temporary and permanent soil anchors will be installed to secure tunnel entrances and other retaining structures. VSL, working as subcontractor with Marti Spezialtiefbau, is supplying and installing the anchors. The large quantity represents a substantial but positive challenge for VSL's local production and logistics facilities. ■ **Contact: hannes.mueller@vsl.com**

Switzerland

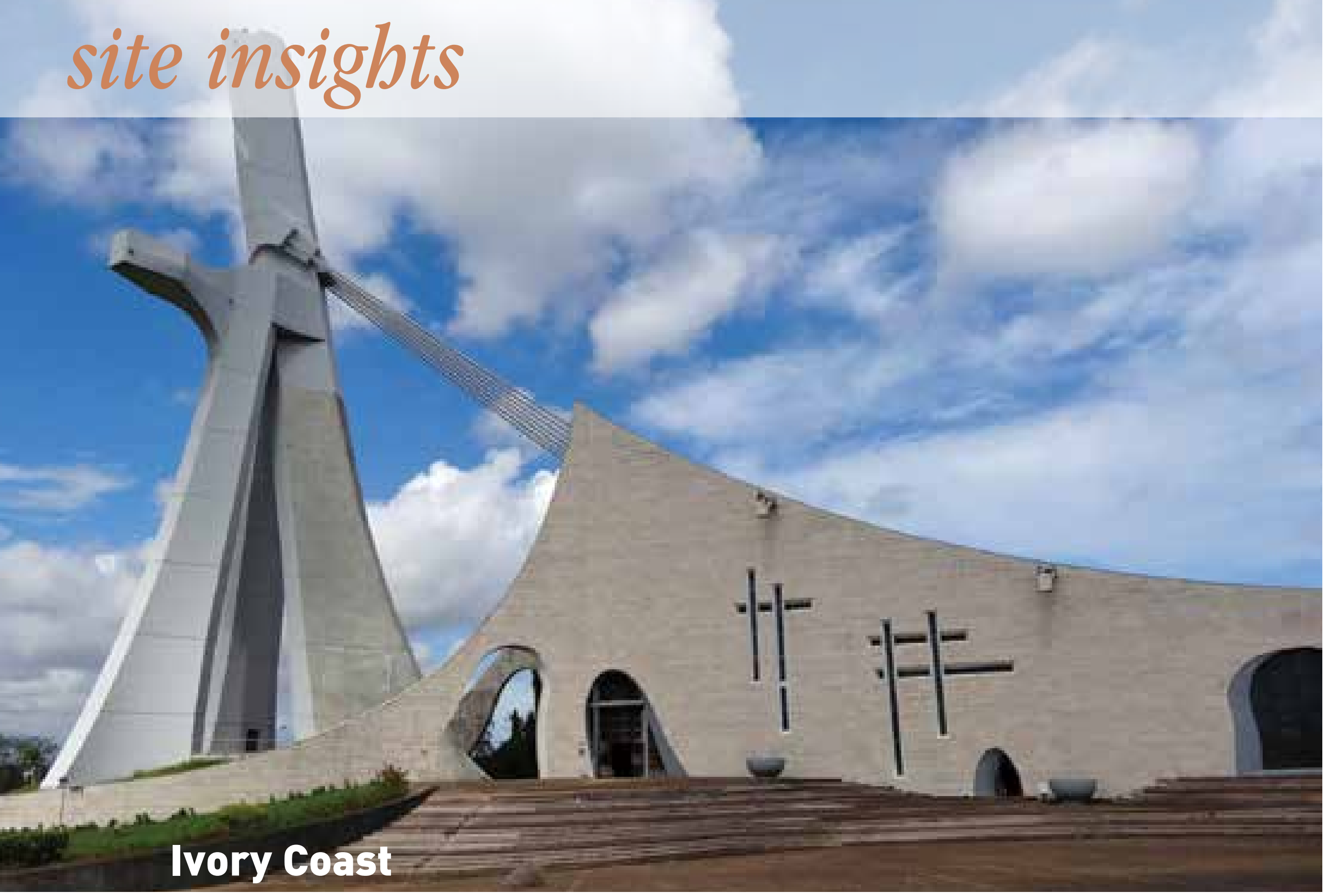
High-tech tendons

→ **The latest generation of prestressing tendons** is being used for two bridges on Zürich's Durchmesserline rail extension. Letzigraben Bridge, which has a total length of 1,160m, has been under construction since 2009 and erection of the 400m-long Kohlendreieck Bridge began in 2012. VSL is subcontractor for the prestressing work on both bridges. Post-tensioning is being done entirely with the latest electrically isolated tendons to ensure maximum corrosion protection. More than 17,000m of tendons will be installed, mainly type VSL 6-31. ■ **Contact: hannes.mueller@vsl.com**

Switzerland

Hospital upgrade

→ **Teams from VSL have recently completed work** for the supply and installation of post-tensioned 6-31 cables as well as elastomeric sliding bearings for the upgrade of a Swiss hospital. Post-tensioned cantilever beams were necessary to take the load of the eight new storeys being added to accommodate 350 employees. In addition, bearings were fitted to isolate some slabs and ensure the stability of the structure in the event of an earthquake. ■ **Contact: Christophe.candolfi@vsl.com**



Ivory Coast

Cathedral challenge

→ **VSL has carried out a full structural assessment of St Paul's Cathedral in Abidjan.** The 3,500m² main area of the cathedral is covered with a roof that is supported by a tensioned cable system attached to a 70m-tall concrete pylon. The nature of the structure made access difficult and so the VSL technicians used rope access techniques to inspect the pylon, stay cables and the top of the roof. The structure was surveyed using Laser Scan technology to create a 3D model. Other techniques used included Ferroscan® to determine rebar positions and chemical tests to assess carbonation. The stay cables were also inspected, including endoscopic surveys to determine their condition. ■ **Contact: abraham.hidalgo@vsl.com**

Ethiopia

Bridge recovery

→ **In the very remote southern region of Ethiopia** a new 128m-long steel bridge crossing the Omo River was built in 2011. Due to construction defaults the bridge collapsed into the river. VSL was chosen to carry out the recovery of the 550t bridge, including the method to be implemented. The bridge was lifted from the water, put on temporary supports and launched 36m into position following repairs. ■ **Contact: m.eljamous@vslme.ae**

Mexico

City landmark

→ **The city of Puebla has celebrated the recent opening of a new landmark,** the Captain Carlos Camacho Espiritu Viaduct. This cable-stayed bridge is more than 500m long and has two pylons, standing 50m high. VSL's scope of work included the supply and installation of the SSI 2000 Stay system and the tensioning of high-strength bars in a project that took just 28 days. The bridge was built by the Puebla state government as part of scheme to transform the region's roads for the benefit of the more than 1.5 million inhabitants. Design was by International Bridge Technologies (IBT) and VSL's client was GH Anderl Consulting & Construction. ■ **Contact: patricio.rangel@vsl.com**

Spain

Record breaker

→ **Three world records will be broken by a 1,620m-long composite bridge** being built for a new high-speed railway in North West of Spain. VSL was awarded several contracts to install a total of 25,000t of the steel structure. The first part of the work was finished in August with the installation of the pier tables on top of the four main concrete piers. At each pier, two 400t segments had to be positioned in a complex lifting, tilting and lowering operations. ■ **Contact: josemaria.martinez@vsl.com**

Panama

PT completion

→ **A 12-month project is nearing completion in Panama City.** The Cinta Costera III project required 560 post-tensioned beams, each 40m long and weighing 90t. The beams contain a total 2,156t of post-tensioned strand. VSL was responsible for the supply of materials, as well as the installation, stressing and injection. ■ **Contact: ignacio.delcura@vsl.com**

Brazil

120m per week

→ **The Aracaré Viaduct is part of the Rodoanel Mario Covas project** in São Paulo. It consists of two decks, each with 52 spans of 30m. The spans will be post-tensioned longitudinally with eight cables of nine strands. The challenge on this project is to complete 120m of bridge deck per week. ■ **bherweg@vslbrasil.com.br**

ELEVATED SEGMENTAL ROAD BRIDGES

Decongesting India's roads

India's economic surge has resulted in a massive increase in the number of private vehicles on its roads, overwhelming the transport infrastructure. Use of VSL's precast segmental construction technique to build elevated roads and highways is an efficient option, fast and safe.

The 3.3 million kilometres overall length of the Indian road network makes it the second largest in the world. About 65% of India's freight and 80% of its passenger traffic is carried by road. National Highways constitute just 1.7% of the network but carry about 40% of the total traffic. The number of vehicles has been growing at an average pace of 10.16% per annum over the last five years while the road network has grown by only 4% annually[1]. Elevated road and metro construction projects have been initiated to alleviate the heavy traffic in cities such as Mumbai and Bangalore; VSL has been working on some of these challenging schemes.

Above traffic

Avoiding continuous disruption to the traffic underneath is a decisive element in favour of using the precast segmental construction method for both elevated highways and metro viaducts. Precast segmental construction is extremely well suited to large urban bridge projects, allowing the safe and fast construction of high-quality and durable elevated bridges even in confined areas with limited access.

[1] Source : National Highways Authority of India, www.nhai.org

One of Bangalore's longest flyovers

Bangalore – the IT capital of India - is growing into a major metropolis. The government decided to build an elevated highway to improve the infrastructure and provide direct connectivity from the city to the IT offices, in Electronic City, 10km from the busy Silk Board Junction on Hosur road. The 8.05km-long **Bangalore-Hosur Elevated Expressway** was built using the precast segmental technique with the span-by-span construction method. The segments were erected using self-launching overhead gantries, supported on the expressway's piers. Three gantries were in simultaneous operation for the span-by-span erection. VSL's scope of work included the design, fabrication, supply, erection and operation of the three gantries used for span erection, the complete deck erection as well as the provision of geometry control software for the segment production in the casting yard. In addition, VSL provided construction engineering services, produced the shop drawings for segment casting, carried out deck post-tensioning and installed the permanent bearings. The need to build the elevated expressway in the middle of a busy highway with traffic on both sides led VSL to propose heavy-lifting techniques as an alternative to the erection of the gantry by cranes. Assembling and commissioning the main gantry trusses at ground level substantially reduced the risks of working at height, and greatly reduced the usage of cranes and other lifting equipment. As such, the method is considerably safer than conventional means for this type of work. Precast segmental construction on such a large project demonstrated that it is one of the most appropriate solutions for major cities with a high traffic density.

Complex construction for a tollway

VSL has built a 4.2km elevated highway in Bangalore for **Navayuga Bengalooru Tollway** Private Limited. Building the precast segmental viaduct involved erection of 1,421 segments over 120 spans using the VSL overhead launching gantry and included the installation of 1,625t of post-tensioning. Built along the central median of the existing National Highway, the viaduct passes through densely populated residential and commercial areas where traffic is heavy. About two thirds of the spans have horizontal curvature including several S-curves with a minimum radius of 360m combined with a 7% cross-fall and 3% gradient. The complex construction

of the viaduct created great challenges. Minimising the construction period was critical as it was a build, operate and transfer project. VSL had committed to a 2.5-day per span erection cycle but achieved even faster installation, with an average cycle time of less than two days a span. The record was a 36-hour cycle time and peak production of 18 spans in one month. VSL demonstrated speed, accuracy, quality and safety on the project and continuously engaged with the main contractor on all issues, ranging from the casting of segments using VSL's geometry control software to erection, surveying and final span alignment.

An innovative cable-stayed bridge in the heart of Mumbai

Mumbai Metro One Private Limited is implementing a state-of-the-art mass rapid transport system for the city of Mumbai. This line crosses the elevated Western Express Highway, where it requires an 83m span for which consultant Systra MVA designed a cable-stayed bridge. Its location near the future WEH Station is on a very congested site in a highly populated area with heavy traffic, dense crowds, underground utilities and a pylon height limit due to the proximity to the airport. VSL built the superstructure for the crossing, which is designed with a cast-in-situ U-shaped deck built in balanced cantilever with stay cables supported from two pairs of pylons. The VSL SSI 2000 Stay cable system was used together with the third generation of VSL's patented saddle.

VSL designed a special jig to achieve the highest levels of positioning accuracy when seating the saddles. The balanced cantilever cast-in-situ concrete bridge deck was built using two pairs of form-travellers. Heavy traffic moving day and night on the highway below created a challenge in the form-traveller design. It was essential to ensure that crews could work safely 24 hours a day whilst allowing the traffic below to continue to flow without risk. The form-travellers featured well positioned work platforms to allow the safe execution of all tasks taking place on the structure, including post-tensioning works and stay-cable installation. VSL's teams clocked over 240,000 man-hours safely with zero lost-time incidents.

Minimising temporary works

Difficult traffic arrangements combined with a lack of space at ground level and sometimes poor soil conditions make the elevated highway solution a logical choice. Span-by-span precast segmental erection with a launching gantry is a construction method that minimises the temporary works required during construction while optimising the permanent works design. VSL has an extensive expertise and a large team of experienced and qualified personnel available to manage, supervise and operate its erection equipment.

Optimising costs

Post-tensioned precast segmental concrete bridge construction is an advanced construction method that provides many advantages to the project's management. Construction quality is improved due to factory conditions in which the precast segments are built. Production is more cost-efficient and fast erection rates can be achieved when post-tensioning is external. The method allows better control of construction costs as quantities are optimised, limited equipment is needed and there is less environmental disturbance as only localised working areas and a small footprint are required at ground level. In addition, the materials are easy to recycle at the end of their life. All these factors contribute to reducing the overall project risk for the contractor, the designer and the owner.

VSL has extensive experience in the construction engineering and geometry control of precast segmental bridges. The construction method is fast and versatile, allows highly controlled quality, and avoids disruptions at ground level. All these aspects have made it the preferred solution for many long, elevated highways and metro projects, as they allow securing the schedule and the cost, thus mitigating construction risks. ■

Upgraded access to airport

An upgraded access was needed to connect Bangalore's international airport with National Highway 7 and so the National Highways Authority of India launched a project to build a 22km-long expressway. **The Devahalli Hebbel expressway** has a six-lane elevated viaduct that is 4.5km long, with 7m-wide service roads and two flyovers, each of 500m. Traffic flow between the airport and Bangalore City remained uninterrupted. The project was built under the National Highways Development Programme on a design, build, operate, finance and transfer scheme through a public-private partnership. VSL's scope of works covered the design, fabrication and supply of 12 cells for precasting pier field segments. The project included design, fabrication, supply and operation of a new erection gantry used to build the two flyovers. VSL also adapted and operated one of its existing gantries for the erection of 3.7km of viaduct. In addition, VSL provided geometry control for all three bridges as well as carrying out external post-tensioning, installation and grouting of bearings.

Boosting Chennai's transport

Chennai, formerly known as Madras, has an estimated population of 12 million, making it India's fourth-largest metropolitan city. To provide additional public transport, Chennai Corporation decided to develop a **metro rail project**, connecting the central bus station to the airport. VSL's scope of work on the 6km-long elevated viaduct covered the design, engineering and supply of two launching gantries, their assembly, erection and commissioning as well as the erection of precast segments for 145 spans including all prestressing work. Work also included all associated temporary works and the relocation of the gantries. The maximum span length was 35m and the weight was 407t. The spans were built from precast segments, with the simply supported spans erected using the span-by-span method. The challenging viaduct had to accomodate a tight radius of 150m and a 4% longitudinal gradient. VSL was closely involved with the designer at all stages of the project to achieve the most efficient, reliable and rapid construction. Later stages of the project required VSL to come up with further special methods to launch the bridge over portals, in an operation that had not been part of the original plan. Once again, VSL provided excellent engineering solutions that helped the designer and main contractor achieve the objectives without many changes to the permanent works.

POLYMERIC DUCTS

PT-PLUS® – for enhanced durability

VSL continuously drives improvements of its PT-PLUS® polymeric duct system. New diameters complete the range of ducts to optimise the ducts for each tendon size.

Almost 10 years ago, the *Federation Internationale du Béton (fib)* introduced in its bulletin 33 report the concept of defining a protection level (PL) applied to post-tensioned tendons and categorised the levels as PL1, PL2 and PL3. With proper material selection, the right installation methods and skilled and experienced staff, good corrosion protection can be achieved for moderately aggressive environments (PL1). For a more aggressive atmosphere, full encapsulation of the tendon is required and this is achievable by using leak-tight grout caps and PT-PLUS® polymeric ducts.

PT-PLUS® in bridges: material savings and lower friction

PT-PLUS® was first installed in 1991 when 113km of 100mm-diameter ducting was used on the Storebælt Bridge in Denmark. Following that pioneering bridge, PT-PLUS® ducts have been installed on hundreds of projects in all kinds of environments. The resulting experience – backed up by dozens of tests - shows that the design friction coefficients for PT-PLUS® ducts can be considered 35% lower[1] than for galvanized steel strip sheathing. This reduced friction leads to a better spread of the PT-force and hence to a direct saving in the amount of PT strand, the need for less or lighter anchorages, shorter installation times for threading, stressing and grouting operations.

These savings will vary depending on the nature of the structure but, as an indicator, reductions of up to 15% in PT-steel are possible. The lower friction has also been proved to have a positive impact on fatigue behavior. With the latest revision of the system's European technical approval, VSL has extended its PT-PLUS® range with two new diameters, 65mm and 85mm, in order to optimise the ducts for intermediate tendon size.

[1] $\mu = 0.12$ vs $\mu = 0.18$ according to PT-PLUS® Swiss Technical Approval

PT-PLUS® in buildings: increased productivity

Two VSL systems have combined to become a winning team for slab projects. VSLab® S and PT-PLUS® have an optimised design that ranges from 6-2 to 6-5 tendons and comes with a full set of fast-clipping accessories, reducing the work on the critical path to a minimum. The speed of installation is a major advantage for today's fast production cycles. The flat duct can be delivered to site in continuous coils and the full tendon length can be spanned in just one piece, eliminating the need for duct couplers. Not only is the cost of the coupler itself saved, but also the labour costs are reduced. In a typical 30m-long tendon, only two fast-clip connections to the trumpets are needed. In contrast, classic steel ducting requires six joint connections -duct and duct-trumpet. A full set of other accessories is available for situations where intermediate grouting points are needed or where H-anchorages have to be installed. ■

MahaNakhon: newcomer on Bangkok's skyline

MahaNakhon is a new 77-storey high-rise complex located in the heart of Bangkok's Central Business District.

The combined use of VSLab® S 6-3 and PT-PLUS® is contributing to achieving the accelerated pace set by a tight construction programme that targets completion of the new Bangkok landmark in 2015.

technical report

MITIGATING VIBRATIONS

Disk brakes or rubber pads?

For the last two decades, VSL has taken on the challenge of designing its own damping systems. The design has constantly evolved for better performance, easier fabrication, installation and maintenance, and of course for aesthetic reasons.

With the number of cable-stayed bridges soaring, VSL has been playing an important role in supporting contractors in construction and design checks for these projects. An extensive range of services is offered and VSL also assists consultants with the design of stay-cable components such as anchorages, connection detailing, saddles, deviators and dampers. Two types of dampers are now used to mitigate vibrations on cable-stayed bridges.

Friction or visco elastic?

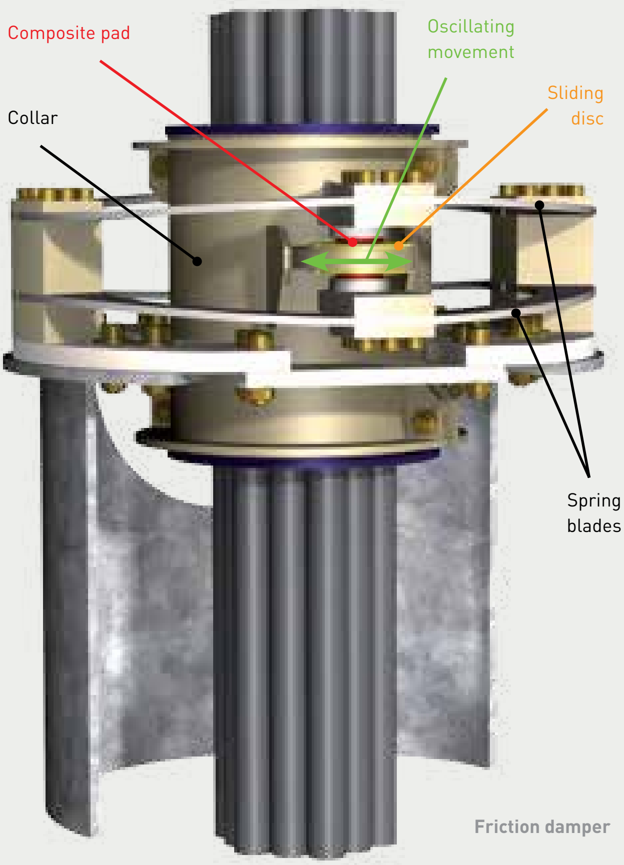
The VSL Friction damper applies the same principles used in disc brakes, dissipating the energy through friction generated between two friction 'partners'. The first is a pair of sliding discs connected via a collar to the tensile member of the stay. It is sandwiched by the second partner, a specially developed composite pad supported by a pair of spring blades that are connected to the external structure of the guide pipe. The VSL Friction damper provides high performance for critical cases or where the damper has to be placed close to the deck anchorage relative to the overall length of the cable. It can easily be adapted to all cable sizes, whether for a new installation or as part of a retrofitting solution. In addition to providing an outstanding performance, the VSL Friction dampers are activated 'only when needed'. This prevents unnecessary wear on the damper under vibrations with small amplitudes that do not affect the stay cables' performance. However, the VSL Friction damper achieves its maximum performance almost immediately once the cable vibration has reached a level that is critical for the cable or the structure to which the damper has been tuned. This damper is the perfect solution for long cables on structures with a high risk of parametric excitation.

The VSL visco elastic (VE) damper suppresses cable vibration by dissipating its kinetic energy through plastic deformation of special damping rubber pads. Each damper consists of a series of pads mounted between a moveable col-

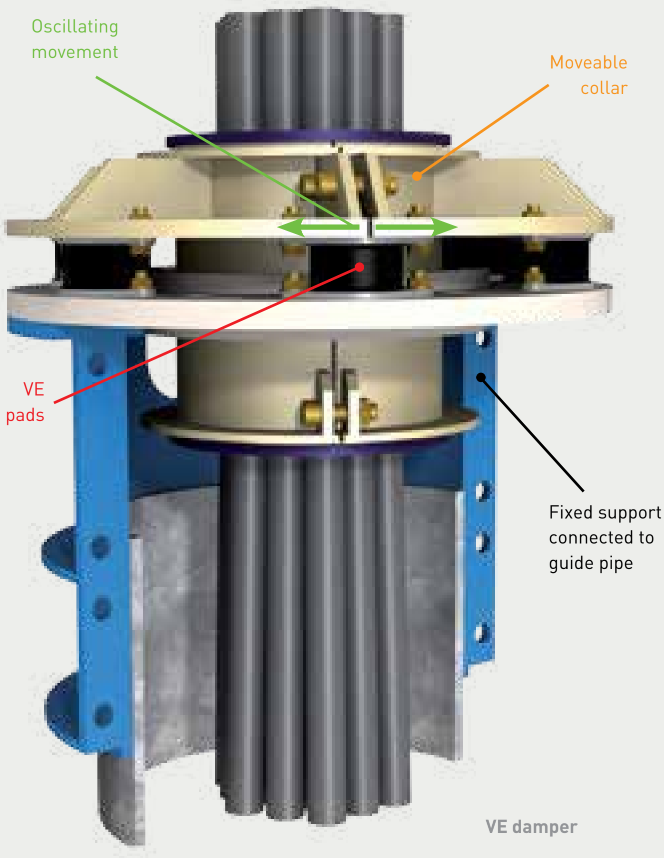
lar attached to the tensile element of the stay cable and a fixed support rigidly connected to the guide pipe. The high-damping rubber pads have a long design life and excellent fatigue resistance. Accelerated ageing tests have demonstrated a life expectancy of 60 years and the pads have sustained 10 million load cycles during fatigue testing. The damper requires only minimal maintenance during its operating life. This allows it to be placed if necessary even at the pylon, where maintenance access is difficult and expensive. The VSL VE damper presents an outstanding combination of simplicity, durability and aesthetic qualities. The installation and maintenance can be performed with minimum effort and hardly any traffic disturbance. As with the Friction damper, all components are two half-assemblies. The main components consist of the collar assembly, rubber pads, damper support and guide-pipe brackets.
Generally speaking, the combination of the two systems allows VSL to cover the whole range of cable lengths and damping requirements.

Fully pre-assembled

While the design concept has remained essentially the same over the years, constant improvements have been made to the connecting elements, damper supports, guide-pipe fixing parts and anti-vandalism pipe details.
Recent developments have included further improvements in damper detailing for faster installation and easier maintenance. Dampers can now be fully pre-assembled under factory conditions with stringent quality control. Options include the availability of dampers with special movement-limiting devices to protect both the damper and the cable against rare but extreme events.
Another improvement concerns the anti-vandalism pipe, which was originally a continuous element covering the damper system. It is now divided into several components to provide better access during damper installation and maintenance.
Friction dampers and VE damper systems share identical external components, which allows both types of VSL dampers to be used on the same structure without visual difference.
Clients, manufacturers and designers have contributed to these improvements, which are the result of invaluable feedback, comments and collaboration. The end result is the ability to carry out pre-assembly, a simple configuration, better functionality and enhanced aesthetics. ■



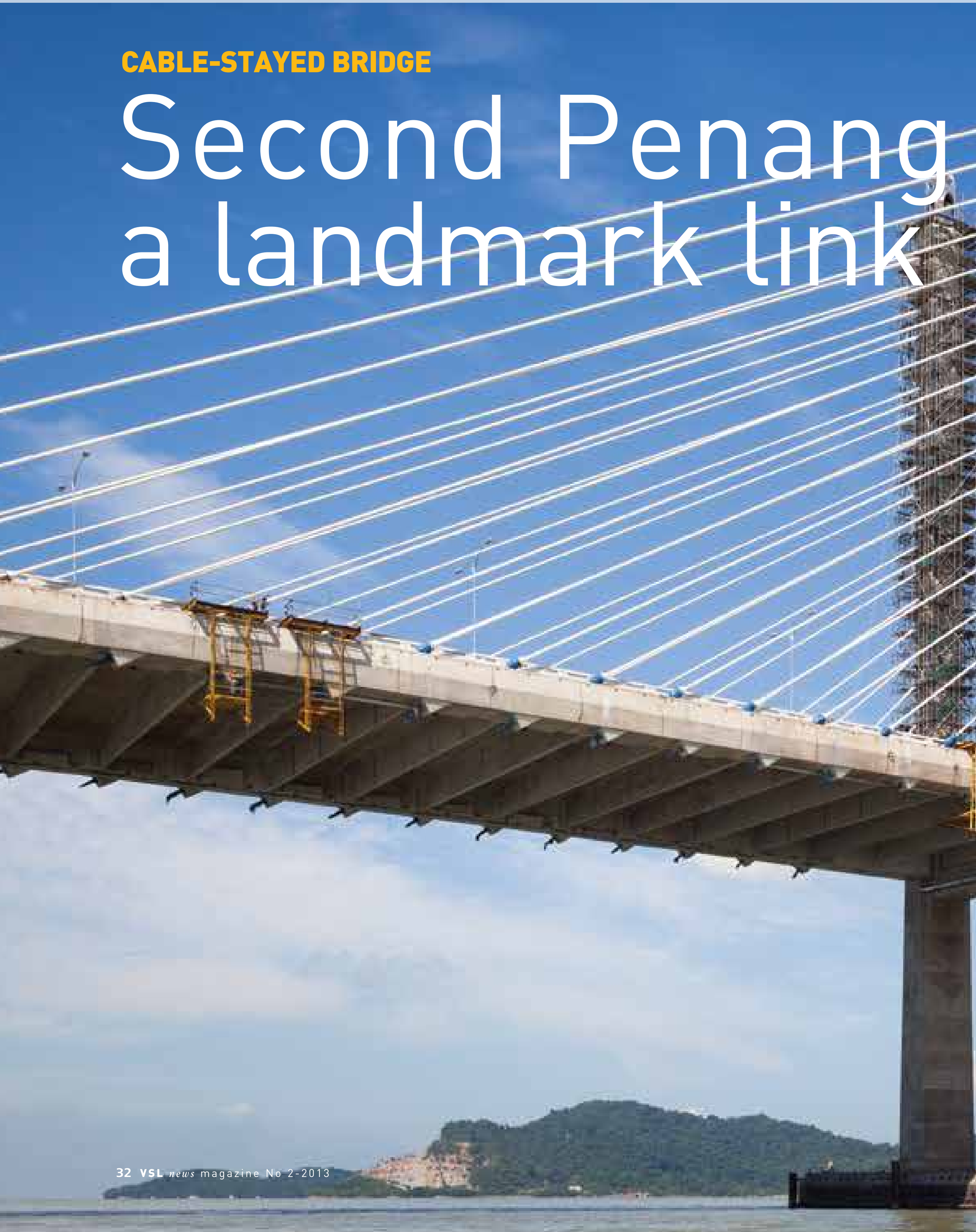
Friction damper

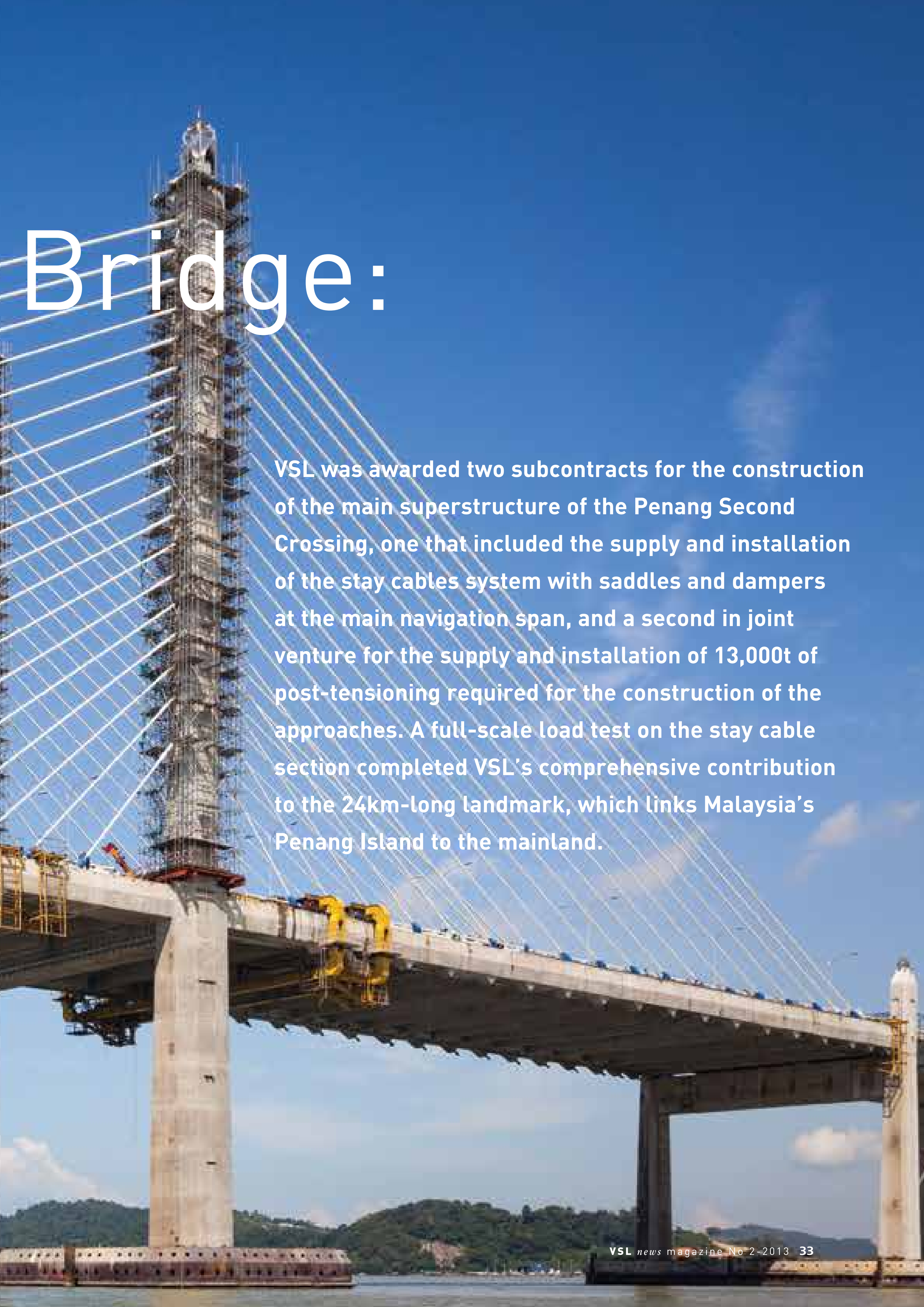


VE damper

CABLE-STAYED BRIDGE

Second Penang a landmark link





Bridge:

VSL was awarded two subcontracts for the construction of the main superstructure of the Penang Second Crossing, one that included the supply and installation of the stay cables system with saddles and dampers at the main navigation span, and a second in joint venture for the supply and installation of 13,000t of post-tensioning required for the construction of the approaches. A full-scale load test on the stay cable section completed VSL's comprehensive contribution to the 24km-long landmark, which links Malaysia's Penang Island to the mainland.

1 Define the needs for a link to the mainland

Penang is a major rapidly growing hub in northern Malaysia for industry, commerce and tourism. This has led to a major traffic bottleneck at the existing Penang Bridge, badly restricting further development. A project to build a second crossing came to life to cross the Penang Strait from Penang Island to the mainland. The Penang Second Crossing comprises a main cable-stayed section approached by viaducts. The overall length of the bridge is 24km and its main span is 250m, flanked by 117.5m-long side spans. The height of the pylons is 100.6m, of which almost 68m is above deck level.

2 Use form-travellers to build the main span

The deck of the main span was built with underslung travelers. VSL supplied and installed all prestressing and the stay cables for the main bridge.

3 Use of overhead gantries for the span-by-span construction of the approaches

The viaducts are made up of twin parallel structures and their length over water is approximately 17km. Each viaduct comprises a trapezoidal segmental box girder typically spanning 55m between piers. Construction by the match-cast segmental span-by-span method used four gantries to erect the 8,092 precast segments. VSL formed a JV to handle the 30-month post-tensioning and grouting contract for approximately 13,000t of strands.

4 Install the stays with innovative methods

In total, 144 stay cables were installed together with the VSL SSI 2000 Saddle System. The shortest stay is 44m and the longest is 262m from anchorage to anchorage. VSL used the pulling system method to install the strands, with winches placed at the pylons and on the deck. Two winches were placed on top of the pylon. One was for pulling the strand from deck level at the side span to the entry face of the saddle. The other pulled a winch cable from the main span's deck on the other side of the pylon. The strand being installed from the side span was then attached to a pilot wire which was connected to the winch from the main span. This strand was then pulled through until it reached deck level on the other (main span) side. The rapid progress of construction has demonstrated the ease and the efficiency of the VSL stay cable system.

5 Install dampers to mitigate vibration

VSL's Visco elastic dampers have been installed on all 144 stay cables. The VE damper suppresses cable vibration by dissipating its kinetic energy through plastic deformation of special damping rubber pads. Each damper consists of a series of pads mounted between a moveable collar attached to the tensile element of the stay cable and a fixed support rigidly connected to the guide pipe.

6 Prove structural integrity

In association with FT Laboratories, VSL instrumented the bridge for and collected data during a full-scale load test on the main bridge to verify the structural integrity before the crossing opened to public. The test involved bringing 17 trailer trucks, loaded to a total weight of 595t, onto the bridge to test the behaviour of the cable-stayed section. Design of the load-test system was aimed at measuring the bridge's static and dynamic responses to vehicular loads, as specified by the designer.

7 Install sensors and analyse the results

The deflections of the decks and pylons were measured by means of sensors installed on the bridge designed to collect all types of data, such as wind, temperature, bridge deck acceleration, displacement, stress or strain, stay-cable forces and the tilt angles of the pylons and piers. The measurements were transferred to a data acquisition system via data loggers that collected information across a distance of 150m-180m. The collected data was transmitted to a control and display system for verification and storage. All data collected from the load test have been compiled and compared with the theoretical figures provided by the designer.

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