

NEWS

MAGAZINE

ONE

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LNG tank Formwork System

Moses Mabhida Stadium

	SUSTAINABLE	4	
	DEVELOPMENT		
	Assessing sustainability	4	
	FACTS&TRENDS	6	
	EIT: Worldwide first	6	
	R&D: No voids		
•)	COVER STORY	8	
	Post-tensioning solutions		
	for nuclear containments Addressing the new generations' challenges		
	SITE INSIGHTS	16	
	Australia: Six months ahead	16	
	New Zealand: Staged delivery	17	
	Abu Dhabi: Parisian prestige	20	
	Spain: Tight squeeze for a TBM	25	
	R&D	26	
	New LNG tank Formwork system: One system, one cycle		
	FOCUS	28	
	Fast track road construction with PPCP		
	TECHNICAL REPORT	31	
	Testing the SSI saddle		
	TECH SHOW	32	
	We shelter the fun		
	The Moses Mabhida Stadium in South Africa		
	VSL placed the arch above the stadium		
	and lifted the cable net roof structure		



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Cover photo: Shin Kori 1-2 nuclear plant, Korea

NUCLEAR 8



TANK FORMWORK



STADIUM 32

EDITORIAL

VSL, a name that is recognised and highly valued

For more than 50 years, VSL's core strategies have been research and innovation, technical development and achieving high quality to serve our clients. Today more than ever, our key assets are our R&D department in Subingen, Switzerland, as well as our Technical Centres in Singapore and Saint Légier, Switzerland, which bring together over a hundred highly skilled engineers and technicians. They allow us take on the most ambitious technical challenges of building today's infrastructures.

Our teams in 50 countries throughout the world focus on optimising each structure from its very start. Later, during construction, our sophisticated method statements help guarantee project schedules, quality and safety.



Clients can count on VSL to mobilise all its technical resources from the outset to optimise costs and other key factors for successful projects, and to minimise the risks involved in their investments.

This latest issue of our magazine is showing the daily efforts of our technical teams and R&D engineers to develop systems that serve the booming worldwide nuclear industry and meet a growing requirement for the construction of LNG tanks.

VSL endeavors to ensure that its name on a project is recognised and highly valued as a global guarantee of quality, technical performance and reliability both during construction and in terms of long-term durability, with minimised maintenance costs. At the same time, there is a focus on sustainability and achieving the lowest possible environmental impact. All members of VSL staff make this their priority.

SUSTAINABLE DEVELOPMENT

Assessing sustainability

Initial efforts have been focused on raising awareness of sustainability issues through education, training and encouraging changes in behaviour through green initiatives. Even small individual improvements become major gains. How to measure these efforts?

Sustainability covers a complex and wide-ranging set of issues, and VSL has a clear concept of what sustainability means and does not treat it as a set of easy to manage tasks.

The Actitudes initiative focuses on SD actions across seven different themes:

- Foster a trusting relationship with our clients, based on consideration, transparency and innovation

4

- Incorporate risk management into the day-to-day running of the company

- Lead our business sectors in terms of occupational health and safety

 Develop our employees' skills and promote equal opportunity
 Establish balanced, long-term relationships with our partners, suppliers and subcontractors
 Ensure that our businesses

respect the environment (design of works)

- Participate in the economic and social life of the regions where we operate.

However, straightforward measurement is useful if it describes real impacts and improvement. Which is what VSL has done, with the two main tools developed to measure the performance.

Qualitative approach

The first one is a self-assessment carried out annually by each operating unit (typically covering



one country) usually by the Administration, Finance and QSE Departments. Each of the 42 actions is measured against a performance criteria to assess the current situation and set an improvement objective for the coming year. These assessments are then reviewed by the Regional Management for consistency and accuracy before being consolidated, based on turnover, by the VSL Group. Following this a random sample of the selfassessments are subject to an external audit. Each Actitudes action is graded as 1 to 4 with 1 being the minimum acceptable standard (e.g. legal compliance) and 4 applying to a mature system, achieving excellent results and incorporating a comprehensive feedback loop. Level 4 can be

considered as 'goal achieved' however continual improvement is an integral part of this so the work never stops.

Quantitative approach

The other main tool is Enablon, a software used to report the performance data online. The content of the report evolves over time as performance improves and priorities change. Reporting is also carried out annually, however only the largest operating units report representing 80% of the turnover of the group (which can broadly be translated into 'impact'). The report covers information such as energy use, waste generated, staff development, and injuries. The reporting is again completed by the Administration, Finance and QSE departments, and is approved by a senior manager.

Applying a sustainable development approach to VSL's activities will not only contribute to reducing the environmental impact of our activities but will also reflect

of our activities but witt also reflect the attitudes of an increasing number of VSL clients and stakeholders. Self-assessment carried out at group level in 2008 was complemented by a number of VSL subsidiaries carrying out their own self-assessment at the end of 2009 to monitor progress and set new objectives. The exercise allows the whole company to recognise and share best practices and to identify areas for improvement on which future efforts can be focused.

KNOWLEDGE MANAGEMENT Tips & tricks to share



emo-tech is Intrafor's newly implemented tool aimed at collecting and sharing tips and tricks of the trade that are developed on individual projects, but which disappear with the project's completion. It keeps track of the knowledge and allows sharing throughout Intrafor (and VSL) of experience, solutions, ideas and good practices, including safety measures.



RISK MANAGEMENT Drawing the line

f a picture is worth a thousand words, then a 3D drawing must be worth a million...

Development of new cost-effective technologies now allows VSL and Intrafor to use 3D tools for improved risk management. For example, applying the new approach to foundations enhances comprehension and planning of complex projects, situations and details, resulting in better preparation, understanding and explanation. Clients, consultants, contractors and sub-contractors all benefit from the very accurate representations of projects.

ISO 9001 VSL Vietnam certified

SL Vietnam has successfully achieved ISO 9001:2008 certification, following audits carried out by Bureau Veritas (BVQI) on its head office and projects both in north and south Vietnam.

COMPANY SPIRIT VSL at Macau Grand Prix

he Macau Grand Prix is a major annual event, known for being the only street circuit where both car and motorcycle races are held. Race car No. 12, supported by VSL Intrafor logos, successfully completed one of November's events, the Macau Road Sport Challenge.



<mark>DISASTER RELIEF</mark> Help for Haiti

mergency Architects provided help following the devastating Haiti earthquake, sending a team to assess damage to strategic buildings and identify places that were safe for shelter. VSL in Australia supported the work via donations.

AWARD Recognized by government

ong Kong's Labour Department awarded a Bronze Prize to the Central Reclamation Phase III project in the Construction Industry Safety Awards. Intrafor's safety manager Cesar Shum and safety supervisor Jerry Chan received the award on behalf of the joint venture team running the project. Next year they are "going for gold!".

ENVIRONMENT Minimising impact

ivil project staff members from VSL United States are part of a team designing and building the Foothills Parkway Bridge No. 2 in the Great Smoky Mountains National Park. One of the key reasons for choosing the proposed design was that it accommodated the unique challenges of the site and the strict requirements to minimise environmental impact. This was imperative given the bridge's sensitive location on a mountainside in the densely wooded national park.

FACTS & TRENDS

EIT Worldwide first



→ Geneva's Lect Viaduct marks the world premiere for the combined use of prefabricated segment construction together

with electrical isolation of posttensioned cables. The project uses a special EP sheath coupler developed for this type of work by VSL's R&D teams in the USA and Switzerland. Preliminary laboratory tests showed that the system could provide a category C structure while allowing flexibility during installation. Construction confirmed the concept's theoretical behaviour and that the bridge met EIT requirements. VSL's construction of the viaduct is part of a five-year project to develop Geneva's railway network. The 330m-long S-shaped structure includes pronounced curves at entry and exit. VSL has installed about 85t of strands as well as 4,600m of PT-Plus[®] ducts and 1,200 duct couplers. Contact: christophe.candolfi@vsl.com

Dampers Staged by client

→ The Korean highway authority responsible for the Incheon Bridge decided to display samples of VSL dampers at its showroom following successful installation on the bridge. The cable-stayed bridge was the first project to combine both VSL friction dampers and Gensui dampers. This key project is expected to create other opportunities for dampers on forthcoming cable-stayed bridges in the country. ■ *Contact: thomas.cheung@vsl.com*



Corrosion Hong Kong first

ightarrow VSL was recently awarded its first corrosion protection contract in Hong Kong for the redevelopment of Kai Tak, the site of the former international airport that closed in 1998. Three different types of corrosion protection systems will be used by VSL on the project. The impressed current cathodic protection method will protect the existing pile caps of the taxiway bridge. A sacrificial anode cathodic protection system will be provided on a newly-installed sewerage pipeline to be laid along the former runway. Thirdly, a complete corrosion monitoring system will be installed inside the caissons of future seawalls. Contact:

thomas.cheung@vsl.com

Bars Joining forces

→ Tysan Foundations awarded VSL a contract for the supply and installation of 75 temporary ground anchors as part of an extension to the Singapore International School in Hong Kong. Intrafor carried out the



drilling works while VSL's teams were responsible for the installation and stressing of the anchors in a coordinated joint effort that delivered the project three weeks ahead of schedule. The project involved Hong Kong's first use of SAS Bars and tight schedules meant that VSL's work had to be carried out in parallel with excavations. Contact: alice.lin@vslintrafor.com

Coupler Approval in Florida

→ The Florida Department of Transportation has approved VSL's new segmental coupler. Its first use will be on the new I-4 Interchange in Tampa, where 18,000 of the couplers will be installed. VSL will also supply the post-tensioning systems. When complete, the structure will connect the Lee Roy Selmon Expressway to Tampa International Airport. The overall project value is US\$450 million. Contact: yballate@vsl.net

Pot bearings & PT Elegant solution



 \rightarrow VSL has provided posttensioning and bearings for this 730m-long new crossing of the River Cacheu in Guinea-Bissau that will replace the old ferry service. Contractor Soares da Costa has completed the concrete structure, an elegant solution designed by Armando Rito. The bridge includes six 86m main spans and two 52m spans built by the free cantilever method as a variable-section box girder. Only bonded posttensioning was installed in the deck although provision has been made for future installation of external cables. The main piers required temporary external cables to balance the deck during construction. The pot bearings manufactured by CTT have capacities of up to 14,500kN and all have been equipped with load cells installed inside the pot to monitor vertical loading. Contact: ralmeida@vslsistemas.pt

R&D No voids



→ A successful test has been carried out in Switzerland on a full-scale mock-up of a posttensioning tendon equipped with grout void sensors. Supplied by SGK (Swiss Society of corrosion protection for VSL) the sensors enable monitoring of the injection and control of grout properties at critical points along the tendon to reduce the risk of undetected defects such as poor grout quality, voids and the presence of any bleed water. Measures can then be taken to remedy any substandard areas of filling before the grout has set. A sensor management unit will be developed to enable the technology to be applied on a pilot project. Contact: vuan.wu@vsl.com

Equipment Multi-purpose rig

 \rightarrow Intrafor is renewing its fleet with a new Klemm KR805-2 multi-purpose environmentalfriendly hydraulic drilling rig, which is suitable for top-hammer and down-the-hole works as well as for jet grouting. In addition to the usual horizontal and vertical movements, it can turn around the axle of the slewing column to allow set-up and alignment in difficult situations such as the corners of buildings. The KR805-2 is equipped with a newly developed computer system to ensure quality and efficiency of jet grouting operations. Contact: sebastien.frebourg@vslintrafor.com



Ground investigation Wireline technique

→ Development of a commercial version of Intrafor's own directional coring system started in September 2009 following the delivery of an Atlas Copco BQ wireline drilling system and Reflex EZ-AQ EMS borehole survey instrument. The steerable core barrel was



modified slightly to accommodate the wireline and survey systems. Preliminary testing using the wireline technique on Intrafor's own steerable core barrel system has proved very successful and larger scale testing will be performed to confirm the properties of Intrafor's commercial system. Contact: mp.chan@vsl-intrafor.com

COVER STORY

Addressing the new generations' challeng

Shin-Kori 1-2 nuclear plant in Korea, 2010. VSL is providing the post tensioning design and installation equipment.



The worldwide nuclear market is booming with over 260 containments to be constructed in the next 20 years. Criteria for post-tensioning in this field are the most stringent to be met in civil works to date. The required performance, the difficulty of installation, the layout and the size of the tendons pose unique challenges that have for many of them never been pushed so far in the detail and in the performance. Demonstration of VSL's post-tensioning for the new generation of nuclear plants...



Different tendon layouts allow for compression of the concrete in three directions within the walls.

ost-tensioning for nuclear containments of the new generation is like what Formula One is to the automotive industry, though requiring absolute safe and full performance for the design life of the structure. The principles of post-tensioning for nuclear applications are similar to the ones for other large civil structures; however, the required performance, the difficulty of installation, and the layout and the size of the tendons pose unique challenges that have for many of them never been pushed so far in the detail and in the performance. Nuclear structures demand special designs and methods to meet the extremely stringent requirements for installation and long term behaviour, together with the external controls that are imposed by the nuclear regulators.

The safest ultimate barrier

Generally, nuclear reactors produce massive quantities of heat and require isolation from the

COVER STORY

environment through a dual circuit design. The primary circuit transports the heat between the reactor and the steam generators and is situated inside a nuclear containment vessel. The secondary circuit transports the steam outside the containment, steam that is used to activate the turbines to generate electricity. Among the few reactor technologies available worldwide, one of the most common is the Pressurised Water Reactor (PWR). In this case, the containment is designed to withstand high internal pressures that would result from a leakage of steam or an accident. Such pressure applied to the inside surface of the containment cause tensile forces inside the containment walls. that are often offset in the design principles by the use of post-tensioning.

This post-tensioning is typically made of a layout of horizontal loop tendons, vertical tendons, and dome or gamma tendons, depending on the containment design. This combination of tendons withstands design pressures of typically 0.4MPa. Unbonded or bonded posttensioning tendons may be used: the choice depends on the specifications and on the technology.



VSL's experience in the nuclear civil business includes 58 references in nuclear containment structures, of which 34 use the complete VSL anchorage system and installation. The highly specialised pool of VSL's technicians and engineers has the experience and the qualifications required to carry out all special operations of supplying and installing the post-tensioning on nuclear containments to the highest level of quality and safety. A proactive R&D policy, with an integrated R&D team, allows VSL to carry out independently important projects such as the fullscale mock-up in Gien (see box).

Anchorages are key elements for post-tensioning systems. VSL provides various types to suit each client's requests, such as replaceability of strand, friction values, and containment geometry. VSL's systems, all designed according to ETAG 013 criteria, provide excellent performance at



SYSTEMS FOR 3D GENERATION CONTAINMENTS Testing on a slice

VSL has anticipated the current boom in the energy market by setting up a full-scale mock-up of a slice of an EPR-like containment to demonstrate new capabilites. It is the largest R&D investment ever undertaken by VSL.

The testing program and results have demonstrated the efficiency of VSL's range of post-tensioning solutions for the latest nuclear containment designs to suit power stations ranging from 1,000MW to 1,600MW, for the latest generation of containments, including the European Pressurised Reactors (EPR), the VVER, the Advanced pressurized water reactor (APWR) for MHI and Obayashi, and the CPR 1000.

The mock-up was designed as a 2.75m-high slice of a nuclear containment vessel, including 6 different types of post-tensioning tendons of various systems. The radius for the tendons matched the 24.46m outer tendon radius of an EPR. A high-grade C60/75MPa concrete was poured in the walls. The high density of reinforcement within the buttresses led to the anchorages being cast into prefabricated elements to guarantee the accuracy of installation and the quality of concreting. Special installation and checking methods were developed to meet the stringent criteria for the post-tensioning installation. Construction of the mock-up allowed demonstration of the duct waterproofing, adjustment and placement of three different types of ducts: PT-Plus®, low friction



steel sheet ducting and steel tubes. Four tendon types were also installed, using different anchorages, different type and sizes of ducts and different strands. For these tendons, three new designs of casting were developed, all of them meeting the nuclear requirements. The tendon sizes were 6-37 and 6-55, using a maximum of 37 or 55 strands of 15.2 or 15.7mm diameter.





On completion of the civil works, clients and system owners were invited to attend demonstrations covering a variety of site tests:

- Threading test of a tendon with a high vertical deviation simulating the tendons at the vicinity of the containment hatch;

- Stressing with the ZPE 1350 FJ long-stroke jack;
- Comparison of strand installation method between prefabricated and push-through tendons,
- Equalisation of the force in each strand using the Low Force Jack;
- Measurements of friction coefficients for the overall tendon;
- Measurements of the variation in force between strands of the same tendon during stressing, and
- calculation of standard deviations;Validation of various cement grout formulae with different rheology

Anchorages for every nuclear application

values and setting times.

Concerned about environment and sustainable development issues, VSL handed over the mock-up to the city of Gien after completion of the tests. The ring was transformed into a rainwater storage tank and surely it will have long years of water tightness duty in this new role.



of the full scale test mock-up at Gien, 2009

Type of Post- tensioning	Possibility of strand replacement	Design friction coef value*	Performance at ultimate state	Possible monitoring after installation
Bonded with steel duct	No	0.18	111	Grout sensor
Bonded with plastic duct	No	0.14	<i>√ √ √ √</i>	Grout sensor EIT (electrical isolation)
Unbonded with bare strands and steel duct	Yes	0.14	~~~	Force (global or individual force measured during maintenance or permanently
Unbonded with greased and PE sheathed strands	Yes	0.05	~ ~ ~	Grout sensor, EIT or force

* These friction values are generally lower on site and confirmed by a friction test.

COVER STORY

ultimate state and, depending on the type of anchorage and project requirements, can be monitored in different ways, either by means of grout sensors, through electrical isolation, or by force measurement (see table).

Mixing in long and short lengths

The strands in a nuclear structure are subjected to significant deviations due to size and complex pipe penetrations in such structure. A major challenge encountered for the installation of post-tensioning in nuclear containments relates to the arrangement of the strands inside the ducting during their threading. When a LNG structure generally requires only 19 strands, on a 180° layout, a nuclear containment needs up to 55 strands, threaded on a 360° layout. Consequently, once threaded, strands may vary significantly in length -in a magnitude of half the stressing extension-depending on their final position inside the duct whether on the inner or outer edge. When applying post- tensioning, this variation in length may lead to large variations in force from one strand to another.

VSL's R&D team reproduced the situation on a mock-up (see box) and demonstrated that these differences in length could even lead to strand breakage well before the end of the stressing operation if no precautionary measure is taken. Problems were identified and quantified; specific measures were then developed to guarantee the fulfilment of the nuclear requirements, including the implementation of adequate threading methods to mitigate the "mixing" of strands, the use of the



ZPE1350 VSL Jack between inner and outer containment

appropriate lubricant to assist in reducing the friction between the strands, and the development of methods (specific pre-tensioning of each individual strand prior to stressing to full force) to equalise



the force between the strands prior to the full stressing.

To pre-tension each individual strand, VSL R&D team developed a Low Force Jack capable of simultaneously stressing all strands individually and independently at a very same force. This jack achieves a force of up to 10% of the breaking load (28kN per strand). Consequently, at the start of the stressing operation, all strands are loaded with the same force whatever the initial differences in force, lengths, arrangements, and slack between the strands.

For the final stressing, VSL has then developed two types of highcapacity jacks. The ZPE 1350's long stroke allows stressing of the tendon in a single stroke without any need for regripping. The other lighter ZPE 1450 has a shorter stroke and is used where tendon access is difficult. Specific platforms for the stressing operations are provided in case of difficult access and reduced space on site.

Real time black box

More than anywhere else, contractors and clients in the nuclear field not only require safe systems in place but also ask for tangible proofs that procurement and installation of these systems were provided to the highest level without defect. To provide real time control to the operator, the owner and the designer, VSL has integrated a specific monitoring system in its nuclear special equipment, including stressing jacks and grout pumps. For the jacks, this control system is made of individual magnetic load cells installed on each of the tendon strands monitoring the force in real time during stressing operations individually in each strand. These load cells small enough to fit on each and all strands of the same tendon do not require a mechanical connection to the strand and can be

Timely design for complex layout

The main difference between nuclear containment structures and other containment structures such as LNG and LPG tanks resides in the specific shape and function of the nuclear containment and the stringent supply and installation requirements. In order to allow for a perfect sealing and the displacement required for the operation of the containment, several passthrough tubes with specific design are needed. In some cases, the tubes may interfere with or be too close to the post-tensioning layout. VSL's experienced teams provide their services to validate the detailed position on 3D or 2D models. as well as the tendon

seamlessly integrated into the

A special recording system, the

VSL Data Acquisition Unit (DAU),

the stressing data, including the

acquires and continuously records

tendon forces and elongation. Such

a system allows full traceability of

normal stressing operation.

the operation. It uses a personal digital assistant to process the information and store it for further review by a third party. The VSL DAU can be considered as a "black box" (similar to the one of an airplane) that registers all events. In case of unexpected event, issues are identified and remedied.

Heavy duty grouting

The quality of the grouting is of utmost importance to ensure the durability of post-tensioning tendons. When using bonded post-tensioning systems, VSL's cementitious grout provides excellent bonding and protection for prestressing steel. VSL has developed a comprehensive

the design specifications and, if need be, to modify the design for a successful tendon installation on site. Finally, the specifications impose stringent installation tolerances that require the use of pre-cut and pre-bended steel tubes installed on predefined supports fixed to the liner or to the previous cast laver. Should the layout of the tendon cross the concreting level, specific provisions are taken to avoid duct damages while preparing the concreting of the next layer. Close cooperation between the containment designer, the VSL design team and the client's production and design teams are required at all time, since these provisions generate a significant quantity of collaborative work.

radius and the compatibility with

COVER STORY

« We share a similar culture »

INTERVIEW

Jong Cheol Lee, manager of the safety equipment design team for Doosan's Nuclear Business Group.



What is the role of post-tensioning in the design of your nuclear containments?

The containment building of a PWR in Korea is a post-tensioned reinforced concrete structure enclosing a nuclear coolant system. It is designed to contain the escape of radiation in any emergency. The 1.2m-thick containment is the final barrier to radioactive release. The containment building itself is typically an airtight steel and concrete structure enclosing the reactor and normally sealed off from the outside atmosphere. The steel liner is attached to the inside of the concrete containment.

You have worked with VSL for a long time, since the 1980s. Any comment?

Doosan is the only and top-ranked company for nuclear power plants in Korea. VSL is the global number one company for post-tensioning work. The cooperation in Korea between VSL and Doosan has been a great success for the last 20 years. At the beginning, our partner was VSL in the USA and now VSL-Hong Kong has replaced it since the UCN 5&6 project. VSL-Hong Kong is located much nearer and we share a similar culture and time zone and for this reason our cooperation is very strong and well-suited.

You have recently had great success in the Emirates. What are your perspectives about your development within the international market? Korea's highly experienced team can transfer the knowledge gained from the 30 years of successful nuclear industry operation.

What particular skills do you need from your partners for this international development? We will experience quite different working conditions, regulations and cultures on overseas sites. We have to provide very high quality and short delivery times despite these kinds of difficulties and this will not be achieved easily without our partners' cooperation. VSL has so much experience and many branch offices throughout the world and so we are sure that it is well-placed for this. process dedicated to improving and insuring the quality of grouting materials and grouting activities on site: VSL HPI[®]. Optimised grout mixes designed for the specific use and environment, using selected local cements and admixtures have been analysed and optimised for exclusive use in the network.

Additional verification that grouting has been properly executed is provided by the VSL Grout void sensor. It is installed at potentially critical points on a tendon and allows checking the existence of any voids left after grouting. Electrically isolated tendons and PT-Plus® ducts can be provided if required. Extra requirements for duct sealing are met, such as the welding of outlet vents to coupling pipes for steel-to-steel connections without any intermediate pieces.

VSL has been involved in construction projects requiring special skills and innovative engineering solutions since 1956 and has been providing services in the nuclear market since 1974. Integrated quality assurance is the final achievement of the VSL comprehensive services to address clients' challenges, with commitment and reliability. Today's R&D is another proof – if need be.



Jack installation on the vertical tendon at Shin Kori 1-2 plant.

Clients and partners "Ability to cater for modifications!"

INTERVIEW

Pavel Mozerov, technical director of the LAES-2 project for VSL's client Metrostroy

What are the objectives and functions of the post-tensioning system in a nuclear containment? The post-tensioning system increases the load-carrying capability of the nuclear containment to safeguard against any damage that could happen inside the containment. It protects from internal damage while the external shell protects from external damage - even from a plane crash!

Do you see any risks in connection

with this system's installation? No, this system has proved its value. I do not see any risks if there is a competent technical approach and a correct installation.

Why have you chosen VSL on the LAES project?

The system was tendered and VSL suggested a more technically up-todate approach, in which monitoring is also used. The main advantages of



LAES-2 Nuclear Power Station in St Petersburg, Russia The VSL post-tensioning system is being installed on the 67.7m-high inner containment shell at LAES-2. The project meets the latest nuclear containment requirements for post-tensioning and uses 55 greased and sheathed 15.2mm strands, with 76 horizontal hoop tendons anchored in one or two buttresses, 13 extra horizontal tendons in the dome and 50 vertical inverted "U" shape tendons over the dome stressed from a stressing gallery. The system allows checking of the residual load, re-tensioning or replacing the tendons if required, and this at any time during the life of the structure.

VSL's post-tensioning system are its usability and the provision for permanent control with the monitoring instrumentation. Another important advantage is that the greased, sheathed strands can be retensioned, de-tensioned or replaced.

How do you evaluate the cooperation with VSL?

VSL is distinguished by its technical competence. Staff members provide detailed information about how the system will be installed and how it will work. There are no issues with equipment delivery and VSL provides a serious and responsible approach to technical assistance.

In your judgment, what are the prospects for nuclear expansion in Russia?

A massive programme of nuclear plant construction has been created in Russia. As far as I know, 24 or 26 reactor blocks will be built soon. Electricity consumption is increasing in Russia and there is a power shortage in Europe. For example, the Baltijskaya nuclear power plant will supply electricity to nearby countries.

What about technical development in the nuclear industry?

Blocks of the current VVER-1000 design are used for the Leningradskaya nuclear power plant and the same blocks will be built at Baltijskaya. The general director of Rosatom [the state nuclear energy corporation], Mr. Kirienko, said that the aim is to carry out block construction in three to three and a half years. For such a decrease in timescales, it is necessary to develop the construction technology. One of solutions could be preassembly of the reinforcement



cages. As much of the preparatory works as possible should be carried out off site - on site we should only handle the installation. But the difficulty of saving time is that we live in a country with severe winter frost. We must spend time building enclosures around the concrete structure for the winter period. Construction times increase accordingly.

What are you expecting from businesses that apply to tender? Equipment has to be the most upto-date and very manoeuvrable and the production team needs to be highly technically competent. Construction technologies may not be fully worked out even when the technical drawings have been issued by the designer. That's why an enterprise aiming to participate in the construction has to have sufficient engineering staff to be able to suggest the best construction solutions. A requirement for joint work to be carried out on site is that there is sufficient flexibility in the ducting system as well as the ability to cater for modifications occurring during construction - and believe me, there will be many different modifications!

SITE INSIGHTS

Australia

Six months ahead!

→ The Leighton-Abigroup-VSL Alliance has carried out the closing pour at the centre of the main span of the Gateway Bridge duplication, 65m above the Brisbane River. October's closure marked the end of 30 months of construction, six months ahead of schedule. The Alliance's scope covered full construction of the 1.65km bridge including the 260m-long main span, which was built by form traveller. It is one of the world's longest bridges to be

built using the cast-in-situ balanced cantilever method. The adjacent 1980s crossing will be refurbished to give a combined capacity of six lanes in each direction by early 2011. Contact: jdavies@vsl-australia.com.au

<mark>Australia</mark> Eye catcher



[→] Queensland's Ipswich/Logan Motorway Interchange has now been completed, with VSoL[®] walls

providing an eye-catching entrance to a major piece of infrastructure that has involved substantial bridge construction and access ramps. Leighton Contractors awarded VSL a contract to design and supply the VSoL® Retained Earth Walls. The various required finishes for the walls were cast in VSL moulds using form liners, each 2m by 2m facing panel was painted after installation. Design of the walls allows for crash barrier loads. horizontal loads at the abutments while used as formwork at these areas. Contact: bhannan@vsl-australia.com.au

Hong Kong Channel crossing

→ A joint venture of Kaden and VSL won a Highways design and build contract at Tseung Kwan O New Town in December. The project's major feature is a 140mlong channel crossing, whose main span will be precast on site on a flat-top barge for installation by heavy lifting and lateral launching. The 10m-wide bridge has a footpath and cycle track, which can also be used for emergency vehicle access. Contact: lewis.wong@vslintrafor.com

Australia Aqueduct alliance

→ The Pipelines Alliance, comprising Melbourne Water, Fulton Hogan, Jaydo and GHD, engaged VSL to assist in replacing Melbourne's primary sewer. Critical in the upgrade was the construction over the environmentally-sensitive Werribee River of a new sewer aqueduct, adjacent to the heritagelisted existing sewer and Melbourne's high pressure gas pipeline. The new, incrementally-



launched 70m-long, continuous structure has a 5.3m by 5.3m square cross-section with a 4.7mdiameter HDPE-lined circular pipe. The final launch was completed in early December. VSL's scope included precasting and vertical prestressing of the 11 pier units together with 33 precast deck units and the hand rails. VSL also carried out the design, supply, fabrication and operation of the launching system and posttensioning of the structure. *Contact: gioannidis@vslaustralia.com.au*



New Zealand Staged delivery

→ Newmarket Viaduct, which was built in Auckland in the mid-1960s, is being replaced and VSL in New Zealand is part of the Alliance delivering the staged project. The New Zealand Transport Agency awarded the contract in November 2008 to NGA Newmarket, which includes Leighton Contractors, Fulton Hogan, Beca, URS New Zealand, Tonkin & Taylor, Boffa Miskell and VSL. Foundation works of this very challenging project started on the piers in April 2009 and the first of 468 segments were

cast in early May. Cranes erected the first balanced cantilever sections to create a 120m-long deck, allowing assembly of the launching gantry. Segment erection by gantry started in February 2010. The staged construction means that the 680m-long southbound structure will open in October, allowing removal of the existing southbound structure to free up space for the new northbound viaduct. *Contact: patrick.arnold@vsl.com*

NOTE PAD

Deep cut. Two Intrafor diaphragm wall shafts for Hong Kong's harbour area treatment scheme are well under way, including one by cutter in Sai Yin Pun where the rockhead depth is 91m. The 12.3-diameter shaft should be the deepest diaphragm wall ever built which will be exposed over its full height, as bulk excavation will proceed in rock down to 150m. Panels have achieved outstanding minimal deviations of less than 1 in 900, despite massive boulders.

Challenging logistics. Intrafor's work on Hong Kong's Central Reclamation Project includes a wall with a particularly challenging client design requiring unusual reinforcement logistics. Three layers of 50mm-diameter steel mean that conventional lapping of the bars is not feasible. The only solution is to transport, lift and place the 55t. 38m-long cages as single sections using a three-crane multiple lift and paying great attention to safety and detail, including use of bespoke equipment.

SITE INSIGHTS



Malaysia 500 precast units

→ More than 500 precast units have been successfully installed for the Jalan Hang Tuah elevated viaduct on a busy Kuala Lumpur road. VSL worked in joint venture with a local precasting company on a subcontract to cast and erect 37 crossheads and 469 segments for the twin carriageway single-cell box-girder structure. Casting took place 200km from the site and segments were erected using the balanced cantilever method. Erection involved mobile crane use and an AF-65 segment lifter, which was particularly needed on a challenging section where an existing monorail track runs parallel to the viaduct at a distance of just 2m.

India Aggregate transport



→ A 300m-span suspension bridge is being built to carry a conveyor transporting aggregates for a 2,000MW hydro-electric dam on India's Subansiri River. VSL's

scope of work includes the full design of the bridge structure, pylon and deck elements and the design, supply and installation of the 515m-long main cables. The remoteness of the site and the requirement for accurate fabrication led to all special steel components being produced under VSL's strict supervision 1,200km away in Kolkata and brought to site by barge. Treacherous river currents mean that lifting has to take place as soon as the barge is anchored in position. Contact: wilfredo.villanueva@vslindia.com

Hong Kong Anderson milestones



VSL has been achieving a series of milestones since it won a contract over a year ago to design and build nine VSoL® Retained Earth walls totalling 22,000m² in preparation for high-rise housing at the Anderson Road site in Kowloon. The VSoL® walls stand between 25m and 36m high and are being built using 4m² rectangular masonry-finish panels. A major milestone was December's completion of a load-bearing VSoL® bridge abutment. Panel production has continued to push ahead, with 20% of the total delivered by the end of 2009 and 10% of the VSoL $^{\! \rm e}$ Steel system wall area installed. Contact: alice.lin@vsl-intrafor.com

India Complex cycles for BOT project

→ VSL is achieving an average cycle time of less than two days per span - with a record of 36 hours - on a complex 4.2km elevated highway being built in Bangalore for Navayuga Bengalooru Tollway Private Limited, India. Construction time is critical on the build, operate and transfer project and a peak production of 18 spans in January comfortably beat the 2.5 day cycle that VSL committed to. The viaduct involves erection of 1,421 segments using a VSL overhead launching gantry. About two thirds of the 120 spans have horizontal curvature, including several S-curves with crossfalls and a gradient. VSL has achieved 80% completion and has also successfully erected spans for a lay-by area, which includes a challenging 44m span.

Contact: p.shankar@vslindia.com



Hong Kong Air-lifted drilling rigs



→ Two drilling rigs are being mobilised by helicopter as part of a subcontract that Intrafor is carrying out on behalf of LAM Geotechnics. The works involve drilling a vertical hole and an inclined one to obtain geological and geotechnical information for the design of a traffic tunnel as part of capacity improvements at Hong

Kong's border with China. Intrafor is drilling about 315m down to the invert level of the future traffic tunnel. The NQ wireline drilling system will be used once the hole reaches 100m. The client is Hong Kong's Civil Engineering & Development Department and the engineer is Mott MacDonald.

Australia Realigning mountains

Building two reinforced soil walls nearly 20m high for the Conjola Mountain Realignment involved difficult site access as the walls were built on the mountain slopes. The subcontract for BMD Constructions involved VSL's design and supply of 3,500m² of VSoL[®] panels and soil reinforcement. One of the walls was cut into rock and the use of a stepped reinforced soil block allowed minimising excavation costs by reducing the length of the soil reinforcement near the wall's base to approximately 40% of the height. Contact: fwagner@vslaustralia.com.au







Abu Dhabi Parisian prestige

→ Abu Dhabi now houses a replica of France's prestigious Sorbonne University that is designed to emulate the original's educational standards and appearance including the impressive 22m-high cupola. VSL lifted the new 20m-diameter dome to its final 19m level using eight temporary towers with two inclined pulling cables and a retaining back stay. The lifting cables were connected to the dome's compression ring below its centre of gravity. In total 26 of VSL's SLU 40 strand jacks were activated simultaneously to lift the 150t dome. VSL's safe and costeffective strand jacking method allowed work to continue in parallel underneath the load. *Contact: david.gratteau@vsl.com*



Abu Dhabi Access to Formula One

 \rightarrow Yas Island I Abu Dhabi is famous for the Formula One fans as the final race on the F1 calendar. The brand new circuit was opened in October 2009, a few weeks ahead of last year's inaugural race. VSL was heavily involved in the main access infrastructure works on Yas Island working for the main contractor Sixco and their client Aldar on two large packages of 10 + 9 bridges providing 3,000T of post-tensioning incorporated in the many bridges and ramps as well as over 90,000m² of MSE walls. Contact: a dodds@vsIme ae

Scotland Successful ground anchors

→ Following the success of the ongoing Thames Tidal Defence project, Scottish & Southern Energy has awarded VSL Systems (UK) a contract to carry out testing of ground anchors for five dam projects throughout Scotland. The ground anchors, installed at various stages over the past 20 years, have been regularly tested by VSL as part of an ongoing crucial maintenance regime. Site work to carry out the latest testing is taking place in spring 2010. *Contact: david.addison@vsl.com*

<mark>Syria</mark> Power lift

VSL and Kahele Technical Group have worked together in successful heavy lifting works for a power plant close to Damascus. The adopted approach on the challenging scheme involved a special gantry and lifting frame design, which shortened the cycle time by more than 50%. A 250t generator and a 175t turbine had to be installed. Use of a single SMU 330 for lifting and lowering allowed the load to be rotated in midair, without a turntable. The gantry with the suspended load was skidded into position before lowering. **Contact:** rolf.oesch@vsl.com



Abu Dhabi Hangers for dunes



→ The Special Projects Department of VSL has recently completed the first phase of hanger installation at Abu Dhabi's new landmark crossing, the Sheikh Zayed Bridge. The bridge consists of three pairs of steel arches, which are shaped to resemble desert sand dunes. It has a main span of 126m and the twin concrete deck is supported by 36 stay hangers in various sizes up to 6-127. Hanger installation is expected to be completed by the end of 2010. Opening of the bridge will provide a third link between Abu Dhabi Island and the UAE mainland. Contact: felix.blumschein@vsl.com

SITE INSIGHTS



Norway

Strand-by-strand debut

Spennarmering Norge and VSL have combined their expertise to manage a cable-stayed project that introduces strand-by-strand stay technology to the Norwegian market using VSL's proven SSI 2000 system. Bilfinger Berger is main contractor for the Smaalenene Bridge spanning the River

Glomma. A slender 90m-high pylon will support a composite deck with a main span of 142m and an approach span of 102m. The 28 stay cables vary in size from 6-43 to 6-85 with lengths up to 126m. Gensui dampers are to be installed on all stays. **Contact:** felix.blumschein@vsl.com

Switzerland Alternative solution



→ VSL's proposal of an alternative post-tensioning method secured it the contract for work on the Mülimatt sports training centre being built jointly by the Swiss canton of Aargau and the city of Brugg. A particular feature of the Z-6-6 anchors proposed by VSL is that they allow post-tensioning at any intermediate point of the cable. The piers and roof are made from very thin concrete, with 160mm panels forming a "V" shape. VSL's scope of work included the installation of about 100t of stand as well as 15.000m of PT-Plus[®] ducts. **Contact:** christophe.candolfi@vsl.com

Czech Republic Posttensioned gallery

Close coordination was needed for the construction of Prague's Harfa Gallery, with PT works often carried out in four locations simultaneously. The five-storey mixed-use development is in one of the city's best locations, near the 02 Arena, which was another key VSL project. VSL's work at the gallery for main contractor Metrostav has involved installation of almost 100t of PT bonded slab



tendons and multistrand PT. Prefabricated cables were used in areas where there was insufficient space for strand-pushing jacks. Space constraints also dictated stressing from underneath the slabs through openings, which were subsequently reinforced and filled. Contact: pmisek@vsl.cz

Switzerland Seismic upgrade



→ Valais as Switzerland's most vulnerable earthquake region updated its requirements when seismic standards were updated in 2003. Seismic safety measures were evaluated as part of the

refurbishment of the Central Hospital for Haut Valais in Viège. The results showed that the buildings required strengthening. VSL has achieved this by means of 33 vertical post-stressed VSL CarboStress[®] laminates, which are up to 24m long and connect the roof to the foundations. Permanent VSL micropiles had been installed previously to transfer loads directly into the ground for maximum earthquake protection. The proposed method proved to be the most economical and best compliance with the requirement of the owner. Contact: christophe.candolfi@vsl.com

Switzerland New slide for mega move



→ VSL Heavy Lifting has successfully transported a 2,500t tunnel boring machine (TBM)

625m overland to its next location in Biel, Switzerland. Client Herrenknecht opted to move it in one piece rather than dismantle it. The move to the next drilling location required the development of a completely new sliding procedure. The TBM was supported on four VSS-500 liftand-slide skid shoes and propelled by eight SLU-40 strand jacks in 4m cycles at a 'cruising speed' of 7m/h. A bridge had to be lifted off its abutments to allow the 110mlong vehicle to pass along the route, which included curves and slopes of 2.5% uphill and 3.7% downhill. Contact: wolfgang.schroeppel@vsl.com

Poland Silesian viaducts





VSL Polska has supplied and the stay systems for two contrasting viaducts as part of the Sosnica Interchange between the A1 and A4 highways in Poland's Silesia region. The 101m-long WD467a viaduct features an oblique concrete and steel pylon. It has 85t of stays, made up of between 33 and 65 strands, with two sets of seven stays for the main and back spans. Traffic will continue to run underneath on the A4 while the stays are installed. The WD464 viaduct has a 25m-high arch and its six pairs of hangers of up to 55 strands were installed at the end of the year 2009. Contact: m.targowski@vsl.com.pl

SITE INSIGHTS

Argentina

First cable-stayed road bridge

→ VSL Argentina has completed installation of the Río Cuarto cable-stayed road bridge. The bridge is the first of its kind in Argentina using the method of prefabrication for this type of bridge. Its steel pylons were prefabricated before being lifted into position and the precast deck beams were installed on temporary supports, which were removed after stay installation. For the bridge with a 110m main span, VSL supplied and installed 40 stays, using 57t of sheathed galvanised strands and the SSI 2000 system. The owner is Córdoba province's DPV and the main contractor was a joint venture of Paschini Construcciones, Boetto y Butigliengo, Estructuras and Marinelli. The engineering consultants were Setec and Ingroup. Contact: gmalvicino@vslarg.com.ar



Mexico Matching towers

The 28-storey Escondido Tower has been developed by Inmobiliaria Rotacion as the first of three matching buildings at Mazatlan in Sinaloa. Mazatlan is one of the most important ports on the Pacific coast and is known as the 'Pearl of the Pacific'. VSL developed the structural design for the project as well as supplying and installing PT materials. The work involved 62t of 0.5" (12.7mm) strand for the 21,300m² of post-tensioned slabs. VSL Corporation Mexico will continue with the post-tensioning of the other two towers. Contact: ceciliaalto@vslmex.com.mx

Portugal Seismic step forward



→ VSL has taken a major step forward in the repairs market with VSL Portugal's completion of a highly complex project on a key motorway viaduct across the Trancão valley. Bridge owner Brisa decided to carry out strengthening to improve concrete protection and ensure the structure's seismic resilience. Main contractor Soares da Costa appointed VSL to carry out the seismic upgrade and other repairs. The viaduct has a 329m-long deck slab and is supported on cross beams and longitudinal beams, which are

themselves carried by six parallel arches. Project consultant A2P's analysis concluded that the structure could not fulfill seismic safety requirements. The solution was to eliminate intermediate deck joints and provide base isolation complemented by passive damping. The work involved installation of a total of 120 longitudinal and 30 transverse dampers as well as steel beams. The isolation system incorporates a cut-out, calibrated to break under seismic loads while allowing service loadings. Contact: ralmeida@vslsistemas.pt

Spain Three-directional accuracy for a TBM

→ CTT Stronghold (VSL in Spain) has successfully replaced the drilling heads of a tunnel boring machine in the Habaneras shaft, Barcelona. VSL designed a specific transport steel frame for the skidding manoeuvres of both drilling heads inside the gallery, on two skidding tracks. By means of three hydraulic jacks with a 2.4m stroke fixed on the wall of the gallery opposite to the TBM and a flat skidding equipment installed on the transport frame plus two lateral steel extensions, it was possible to achieve the required geometrical accuracies to allow the extraction/fitting of the TBM drilling heads. Contact: jmmartinez@vslsp.com

<mark>Spain</mark> Tight squeeze

→ CTT Stronghold has successfully moved a 1,300t tunnel boring machine (TBM)



and five back-up trailers of 750t through a 300m tunnel scarcely wider than the machine. The 11.54m-diameter TBM for Barcelona's underground system is 12m long with 80m of trailers. The VSS-500 skidding system was used to move the TMB and SLU/SMU to pull/hold the trailers. Tunnel geometry was the most difficult issue as the size of some sections is just 250mm wider than the TBM and there were also different complex curves and a 3% downhill slope. Contact: jmmartinez@vslsp.com

Spain Large production area



Lleida's largest industrial company in Spain, Grup Alimentari Guissona, has begun operations at a new food production complex. VSL was appointed to work with Constructora de Calaf on the design and construction of the latest three phases, which together provide a production area exceeding 120,000m². Key design requirements included live loads ranging from 15kN/m² to 25kN/m² as well as a major reduction in expansion joints with operational temperature ranges of between -20°C and 30°C. Two phases have been successfully completed and the other is under construction. Contact: posso@vslsp.com

Turkey Largest span

→ The 190m-long main span of the Beylerderesi Bridge being built in Turkey's Malatya province is the country's longest ever to use the balanced cantilever method. The 420m-long bridge crosses a deep valley in three spans supported by slipformed piers about 60m high. The superstructure is formed by a 24m post-tensioned double box deck platform, constructed by form traveller. Main contractor for the bridge is VSL's Turkish licensee Mega Yapi on behalf of the highways authority. The project involves about 700t of post-tensioning using tendons equipped with VSL E6-19 anchorages. Contact: byildirim@megayapi.com



R&D

NEW LNG TANK FORMWORK SYSTEM One system, one cycle

Extensive worldwide involvement in the construction of LNG tanks has enabled VSL to analyse data and obtain feedback from site production teams to identify typical and specific problems associated with tank construction, subsequently developing innovative and unique solutions. The optimised VSL LNG tank Formwork system is one such example of this development.

Nowadays, the storage of liquefied gas is provided by two elements: • the primary or inner containment of the tank, which is typically constructed of steel with a high nickel content, aluminium, stainless steel or in some cases post-tensioned concrete to meet the extreme demands of cryogenic conditions. The containment must independently be able to withstand the hydrostatic load of the liquid. the secondary or outer containment, which is most commonly constructed from posttensioned concrete. It is designed to withstand abnormal loads of external origin as well as retaining

the liquefied gas and vapours should there be a fracture of the primary containment.

Comprehensive modular system

VSL has developed a modular system for this secondary containment. It can be used to build entire circular containment structures without the need for time-consuming and costly modifications to the climbform system after installation on site.

The VSL LNG Formwork system is a comprehensive solution providing suitable solutions for the construction of all components of a typical LNG tank wall including



Optimised layout for fast-track construction

The construction schedule is designed to allow for accurate planning and helps avoid delays by optimising the formwork requirements and PT arrangement. The improved quality that results provides greater control to meet the permanent tolerance requirements. Fast construction cycles are achieved as there is no need for additional components to cater for unexpected clashing of post-tensioning and form ties. Faster cycles save time and money. The surface finish is improved due to reductions in formtie relocation holes in the form face. Major adjustments and additional form-tie holes are avoided because the locations of the ducts are taken into account - a form tie cannot be positioned through a hollow duct. This avoids unused form-tie holes, which would have to be closed with plastic plugs leaving marks that would have to be removed. tapered walls with reducing thicknesses, walls of constant thickness and ring beams. Safety standards and national codes have been taken into account with standardised fixed access ladders for increased safety on the climbform. The system is highly efficient with fast and safe stripping and closing as well as easy and quick assembly of the integrated ring beam support.

The system development has been based on clearly defined criteria. Firstly, it was important that the concrete tank construction could be completed without the need for any major modification once the system was assembled and commissioned. This applied to all aspects including lower tapered tank walls, typical wall sections, ring beams and buttresses.

A second factor was to minimise interference with other activities such as post-tensioning and installation of mechanical embedded plates and inserts. Clear, unobstructed access to all work areas had to be provided.

And, as for all VSL developments, safety features are vital, including permanent fixed access to the top working and trailing platform, easy stripping, ergonomic components and an integrated ring beam lowering device.

Optimising tank construction

While designing this new formwork system for tank construction, VSL has focused on five points:

Enhanced safety

The system meets international standards and features safe working areas on the climbform, including a fully-integrated stair ladder, hand-rails and toe boards. The climbing cones with back anchors are designed with consideration of hollow tendon ducts.

Less time on adjustment of form work panels

VSL has optimised the interfaces between watertight formties, climbing cones, tendon ducts and vapour barrier plates. The working cycle has been shortened by minimising the time-consuming adjustment of formwork panels.

Improvement of operational efficiency

The system guarantees an optimised working schedule that brings accurate planning and avoids delays. The fast cone anchor assembly improves the formwork system's operational efficiency. Furthermore, there is no need for additional components to take account of unexpected clashing of the post-tensioning and form-ties. The surface finish is improved due to a reduction in the number of form-tie relocation holes in the form face.

Single system for standard sections and ring beam

The VSL LNG tank Formwork system allows casting of both the standard sections and the ring beam using the same form with simple adjustment and only minor additional elements.

Modular components for more flexibility

The majority of components for the VSL LNG tank Formwork system are modular and there is no need for advanced training to operate them safely and efficiently. The tapered starter walls, vertical shell walls, buttresses and the ring

No modification

beam can all be built without modification of the standard components. Adaptability for variable lift heights and wall thicknesses makes the system suitable for all LNG tanks worldwide. The system may also be used on other structures including piers, columns, buildings and any circular containment structures.

Customer-involved testing

Clients who visit the VSL mock-up gain an invaluable insight into benefits that this new system will bring to their projects. Different site conditions are simulated following a theoretical

- stripping
 closing
 fixing
 adjustments

Mock-up location: VSL Singapore Pte. Ltd. Contact: Michael Jentsch

FOCUS

Fast track road construe

Highway owners and users demand quick and low-cost infrastructure construction with minimal impact on the environment and low long-term maintenance. A VSL precast prestressed concrete pavement (PPCP) can provide the ideal solution with pleasing aesthetics.

Precast and post-tensioned concrete has a proven track record as a durable high-performance product for bridge and commercial building construction. VSL is a leader in the field of post-tensioning and has for decades designed, manufactured and installed durable, state-of-the-art posttensioning systems that meet international standards and approval guidelines.

Rapid opening to traffic

As a result, all it took to apply this experience to road construction projects was to adapt proven technology to produce innovative solutions. Today's infrastructure and road projects need to be built rapidly, not only in terms of how quickly the road can be built but also how soon it can be opened to traffic. Conventional cast-in-place pavement requires several days of additional curing after the concrete is placed before it is strong enough to withstand traffic loading. In contrast, a PPCP can be opened to traffic almost immediately.

The advantages in terms of durability and performance are manifold, starting from the production of the panels and the related quality control right through to installation and post-tensioning on site. The panels are fabricated at a precast plant, ensuring thorough quality control under ideal factory conditions.

Reduced slab thickness and cracking

Reasons for specifying thinner slabs and a borded post-tensioning system include concrete savings, easier replacement or meeting height restrictions where a bridge crosses the road. Prestressing furthermore reduces the tensile stresses. By putting pavements into compression there is less likelihood of cracking, increasing the design life.



ction with PPCP

Traffic flow Traffic flow Joint panel Base panel Multiple Central stressing Panel Base panel Multiple Dint panel

Panel assembly

The precast prestressed pavement consists of a series of individual precast panels that are post-tensioned together in the longitudinal direction after installation on site. Ducts for the longitudinal post-tensioning are cast into the panels. Each of the panels is pre-tensioned in the transverse direction along its long axis during fabrication. The system consists of three types of panels. It is best to provide a flat, stable platform for the precast panels to rest on, although they can span over voids and "soft" base materials.



Base panels

Base panels make up the majority of the post-tensioned pavement section. They are placed between joint panels and central stressing panels.



Central stressing panels

Post-tensioning is carried out at the central stressing panels, where the strands are fed into the ducts. Strands are fed in both directions to the anchors in the joint panels. The strands from either side of the central stressing pockets are then coupled together and tensioned.



Joint panels

The joint panels are located at the ends of each post-tensioned section of pavement. The joint panels contain dowelled expansion joints which "absorb" the expansion and contraction movements of the posttensioned section. The joint panels also contain the post-tensioning anchorage for the longitudinal posttensioning tendons. The anchors are cast into the joint panels on either side of the expansion joint. Up to 100mm of movement can be expected at the expansion joints, so they must be robust. Both armoured joints (similar to those used for bridge decks) and plain dowelled joints have been used, with the choice depending on the expected traffic and slab movements. Dowels across the joint are essential for providing load transfer.

Post-tensioning

The post-tensioning strands are threaded through the installed panels, anchored at the ends and tensioned. Grouting provides an additional layer of corrosion protection for strands and bonds the tendons to the pavement so that the post-tensioning system will remain intact if ever it is necessary to replace a panel. Road construction by means of PPCP provides rapid pavement construction at reasonable cost, with high performance and durability and simple maintenance.

FOCUS







Successful PPCP implementation in Indonesia

The Kanci-Pejagan Toll Road, which is 35km long and includes 40 overpasses, was built in just 14 months and completed in December 2009.

This major project by contractor Adhi Karya (Persero) and investor Semesta Marga Raya (Bakrie Group) forms part of the masterplan for Indonesia's 1,000km Trans Java Toll Road. Kanci-Pejagan is Indonesia's longest toll road and the first ever to be built there with a PPCP. The system was chosen as an alternative to the conforming cast-in-situ rigid concrete pavement. As a result, the slab thickness was reduced from 300mm to 200mm and the lean

concrete was cut from 100mm to 50mm thick. The major considerations for choosing PPCP lay in its quality, speed of construction, durability, reduction of expansion joints and cost-effectiveness.

The toll road has two 12.2m-wide carriageways, with the 8.2m for the two traffic lanes constructed using PPCP while the shoulders are of 200mm-thick cast-in-situ rigid concrete pavement. Each PPCP panel is 2.5m long and pre-

tensioned transversally at the casting yard and then post-tensioned longitudinally on site into 100m-long sections. More than 21,500 panels were manufactured in a 5.2 hectare casting yard. Production reached about 234 panels a day in a 16 hour pouring cycle using 156 moulds in 12 lines and steam curing.

Contact: Johannes Tjintatmijarsa (tmijarsa@vslin.com)



TECHNICAL REPORT

TESTING THE SSI SADDLE Continuous performance

The testing in 2009 of a VSL SSI Saddle under typical cable-stayed bridge loading is now being followed up with a second test to demonstrate performance with extradosed cables.

By the end of March, the VSL R&D team had successfully completed the 2,000,000 cycles of a full-scale fatigue test of the VSL SSI Saddle 6-37 system.

The system simplifies detailing of cable stayed bridge pylons by replacing a pair of upper anchorages with a single saddle that the cables pass through. Current tests are on a saddle with a base radius of 2.4m and an opening angle of 60°. It was fabricated in VSL's Barcelona factory and installed in January in the test frame at Germany's Technische Universität Berlin.

The set-up consists of a full cable specimen with the saddle, two SSI 2000 DR anchorages, two tension rings and saddle transition boxes. Testing involves applying a stress range of 140MPa at 1Hz for two million cycles. The stress range is lower than in the original test but the upper load of 60% breaking strength is significantly higher to



Independently guided and replaceable strands

emulate conditions in extradosed bridges. The specimen's ultimate capacity will be determined by a final tensile test.

In addition to the saddle test, VSL's R&D team is supervising combined fatigue and tensile stay cable tests in three different European laboratories to comply with specific project requirements. The test specifications follow the recommendations of *fib* Bulletin No. 30 and involve specimens of 37, 61 and 85 strands.

In the field

VSL's saddles are manufactured in Barcelona and Hong Kong. In addition to the 20 saddles installed on Catumbela bridge (Angola), 60 saddles (sizes 6-31 / 6-37) were fabricated in 2009 for Delhi's Moolchand bridge (India), Tisza M43 bridge (Hungary) and Mumbai's WEH bridge (India).



Angola Successful completion of first saddle project

The bridge for an expressway crossing the Catumbela River was designed by Armando Rito Engenharia and construction was awarded to a consortium of Soares da Costa and Mota-Engil. The 438m-long cablestayed bridge has a 160m-long main span and its concrete deck is fully supported by two pylons. Each pylon tower integrates ten stay cables and uses saddles for seven, with anchorages for the remaining three. VSL Portugal's work included the stay cables, post-tensioning, bearings and dampers. Contact: cpereira@vslsistemas.pt

Hungary M43 Tisza Bridge shows saddle's potential

The first set of stays has been installed successfully on Hungary's M43 highway bridge, spanning 180m over the Tisza River. The project's highlight lies inside the two 30m-high pylons where the VSL SSI 6-37 Saddle is showing its true potential as an alternative to conventional pylon anchorages. **Contact: benoit.bergel@vsl.com**



TECH SHOW

We shelter the fun

South Africa will soon be hosting the FIFA World Cup ™. VSL's goal in the event was to place the arch above the Moses Mabhida Stadium, Durban and lift the cable net roof structure. Here is how it scored.

Be aware of challenges

32

Situated at the Indian Ocean in Kwazulu, Durban is the second biggest city in South Africa and presents, like no other city the Rainbow Nation. For the FIFA World Cup™, the Moses Mabhida Stadium was built, the second biggest stadium in South Africa seating more than 70,000 fans. The roof structure of the new stadium is exceptional: the giant Y-shaped arch



represents the South African flag. VSL's scope of work was guying of temporary arch support towers; support and tie back of arch during free cantilever erection; lifting and tensioning of cable net roof structure- performed by VSL for the owner South African Football Association and roof contractor Pfeifer Seil- und Hebetechnik Memmingen (Germany).

Act as specialists

VSL was contracted to support the installation of the huge Y-shaped arch and the cable net roof structure. A deciding factor in building the ambitious structure was the ability to provide and install a tremendous amount of strand lifting equipment on time. The central control and monitoring system allowed conducting an orchestra of 100 SLU strand lifting units according a score-like cable net stressing procedure. VSL was involved from the beginning in the design of temporary structures to create task-fit interfaces between permanent/temporary works and the proven lifting system.

33

VSL HEAVY LIFTING

TECH SHOW



Tie down arch splice support towers The 160m-long lateral stays for the temporary towers are made up of six 6-92 cables, stressed with monostrand jacking. To maintain

the verticality of the tower, the stressing had to take place simultaneously from both sides. A control system ensured the same force level on all strands during stressing. The tricky part during installation was to feed the large cables through the adjacent tower.



arch erection used up to four 6-22 cables fitted with SLU-220s for readjustment. The massive forces were anchored through large steel consoles to the concrete base of the arch. The arch was adjusted by pulling or releasing the hinged tip of the temporary towers.





Cater for wind

The support towers feature massive ties to cater for lateral wind forces. Millimetre accuracy was required for the cantilever adjustments. In addition, the arches were supported in the tower tips by a sophisticated suspension system, allowing for vertical movement and making it possible to rotate the cantilevering arch along its longitudinal axis.



VSL HEAVY LIFTING

TECH SHOW



Lower the arch sections The arch sections reached their maximum cantilever in a slightly elevated position. After lifting in place of the closure segment by crane, the arch sections were lowered to close the small gaps and allowed bolting of the last two joints.







Control 50 pairs of jacks Force is nothing without control. The VSL Bravo system made it easy for the operator to guide each of the 50pairs of SLU, climbing up the lifting cables with steadily increasing force to millimetre accurate positioning for pinning.

Use well-proven systems Cable net lifting and stressing used 100 Strand Lifting Units (SLU), made up of SLU-120s, SLU-220s and SLU-330s. All SLUs were specifically prepared to guarantee a smooth overhead operation. Access to SLU suspended above ground between 30 and 100m had to be kept to a minimum.

VSL HEAVY LIFTING

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Jawaharlal Nehru Stadium, Dehli (under construction) roof lifting operations by VSL in India in conjunction with VSL in Switzerland

Stadium support

VSL has been at the forefront of a key technology to shelter sports venues around the world ever since its lift of the very first cable net roof in 1972. Building on the success of that first lift in Munich, Germany, VSL has continued with other important cable net projects. Among the long list of names are the HSH Nordbank Arena (2000), Pusan Dome Korea (2002), Khalifa Stadium, Qatar (2005), Commerzbank Arena Frankfurt (2005), Kuwait Stadium (2006), and Bayarena Leverkusen (2009). The list continues to grow as VSL is - among others - actively involved in Dehli's Jawaharlal Nehru Stadium and Miami's New Marlins Ball Park. For the Soccer World Cup 2010, VSL was furthermore involved in the roof lifting operations for the Greenpoint Stadium in Cape Town, South Africa, with a capacity of 68 000.

It will host six first-round matches, one second-round, one quarter-final and one semifinal match. In the near future, projects will be carried out in Warsaw and Chorzow in Poland.



The retractable roof of Miami's new Marlins Stadium will be a welcome feature after the team suffered record rain delays in 2009. Lifting of girders to support the retractable roof is being carried out by the Florida office of VSL United States in conjunction with VSL Switzerland, which is supplying equipment and technicians. The largest of the girders, which weighs 1,450t, has been placed successfully. In total, eight segments will be raised using SLU 330 strand lifting units. VSL is also supplying and installing the post-tensioning for the girders.

VSL will soon be carrying out works on the National Stadium, Warsaw in Poland, in preparation for the 2012 UEFA European Football Championship, for the JV of Cimolai, Monostal and Hightex.

HEADQUARTERS

VSL International Ltd. Saegestrasse 76 CH-3098 Köniz - Switzerland Phone: +41 58 456 30 00 +41 58 456 30 95 Fax:

Americas

ARGENTINA

VSL Sistemas Especiales de Construcción Argentina SA **BUENOS AIRES** Phone: +54 11 4326 06 09 Fax: +54 11 4326 26 50

ROLIVIA Postensados de Rolivia San Miguel, LA PAZ Phone: +591 2 27 70 338 Fax: +591 2 27 96 183

CHILE

VSL Sistemas Especiales de Construcción S.A. SANTIAGO Phone: +56 2 571 67 00 Fax: +56 2 571 67 01

COLOMBIA

Sistemas Especiales de Construcción Ltda. BOGOTA Phone: +5716209634 Fax: +57 1 620 58 16

MEXICO VSL Corporation Mexico S.A de C.V MEXICO Phone: +52 55 55 11 20 36 Fax: +52 55 55 11 40 03

PFRII Sistemas Especiales de Construcción Peru S.A. LIMA +51 1 349 38 38 Phone: +51 1 348 28 78

UNITED STATES VStructural LLC BALTIMORE, MD Phone: +1 410 850 7000 Fax: +1 410 850 4111

Fax:

VENEZUELA Gestión de Obras y Construcciones C.A. CARACAS Phone/Fax: +58 212 941 86 75

Africa

FGYPT

Matrix Engineering Company CAIRO Phone: +20 2 344 19 00 Fax: +20 2 346 04 57

SOUTH AFRICA

Tsala-RMS Construction Solutions (Pty) Ltd **JOHANNESBURG** Phone: +27 11 878 6820 Fax: +27 11 878 6821

Europe

AUSTRIA Grund-Pfahl- und Sonderbau GmbH HIMRERC Phone: +43 2235 87 777 Fax: +43 2235 86 561

CROATIA Tehnički projekt d.o.o. 10000 Zagreb Phone: +385 1 4664 586 Fax: +385 1 4664 549

CZECH REPUBLIC

VSL Systems (CZ) Ltd. PRAGIIE Phone: +420 2 51 09 16 80 Fax: +420 2 51 09 16 99

FRANCE VSL France S.A. LABÈGE Phone: +33 05 61 00 96 59 Fax: +33 05 61 00 96 62

GERMANY **VSL Systems GmhH** BERLIN Phone: +49 30 530 28 06-0 Fax: +49 30 530 28 06-99

GREAT BRITAIN VSL Systems (UK) Ltd. BEDFORDSHIRE Phone: +41 58 456 30 30 +41 58 456 30 35

NFTHERI ANDS Heiimans Beton en Waterhouw B.V. ROSMALEN Phone: +31 73 543 66 02 Fax: +31 73 543 66 11

NORWAY Spännarmering Norge AS RUD Phone : +47 98 21 02 66 Fax: +47 67 17 30 01

POI AND VSL Polska Sp. z.o.o. WARSZAWA Phone : +48 22 849 22 09 Fax: +48 22 849 02 23

VSL Sistemas Portugal Pre-Esforço, Equipamento e Montagens S.A. S. DOMINGOS DE RANA Phone: +351 21 445 83 10 Fax: +351 21 444 63 77

VSL GEO Sistemas de Aplicação em Geotecnia SA S. DOMINGOS DE RANA Phone: + 351 21 445 83 10 + 351 21 445 83 28 Fax:

SPAIN

CTT Stronghold BARCELONA Phone: +34 93 289 23 30 Fax: +34 93 289 23 31

VSL-SPAM, S.A. BARCELONA Phone: +34 93 846 70 07 Fax: +34 93 846 51 97

SWEDEN / NORWAY Internordisk Spännarmering AB VÄSTERHANINGE Phone: +47 98 21 02 66 Fax: +47 67 17 30 01

SWITZERLAND VSL (Switzerland) Ltd. SUBINGEN

Phone: +41 58 456 30 30 Fax: +41 58 456 30 35

VSL (Suisse) SA SAINT LEGIÉR Phone: +41 58 456 30 00 Fax: +41 58 456 30 95

TIIRKEV Mega Yapi Construction & Trade Co. Ltd ANKARA Phone: +90 312 490 90 66 Fax: +90 312 490 90 55

Middle East

SYRIA Kahaleh for consulting engineering DAMASCUS Phone: +963 11 50 40

Fax: +963 11 22 14 595 **UNITED ARAB EMIRATES** VSL Middle East LLC DURAL HAF

Phone: +971 4 885 7225 Fax: +971 4 885 7226

DOHA, QATAR Phone: +974 423 1117 Fax: +974 423 1100

Asia

VSL LOCATIONS

BRUNEI VSL Systems (B) Sdn. Bhd. **BRIINFI DARIISSALAM** Phone: +673 2 380 153 / 381 827 Fax: +673 2 381 954

CREATING SOLUTIONS TOGETHER

CHINA PRC VSL (China) Engineering Corp., Ltd. HFFFI Phone: +86 551 382 29 18

Fax: +86 551 382 28 78 **HONG KONG** VSL Hong Kong Ltd. CHAI WAN Phone : +852 2590 22 88

Fax : +852 2590 02 90 Intrafor Hong Kong Ltd. CHAI WAN

Phone : +852 2836 31 12 Fax: +852 2591 61 39

FT Laboratories Ltd. PING CHE Phone: +852 2758 48 61 Fax: +852 2758 89 62

INDIA VSL India PVT Ltd. CHENNAL Phone: +91 44 4225 11 11 Fax: +91 44 4225 10 10

INDONESIA PT VSL Indonesia IAKARTA Phone: +62 21 570 07 86

Fax: +62 21 573 75 57 JAPAN VSL Japan Corporation TOKYO Phone: +81 3 3346 8913 Fax: +81 3 3345 9153

KOREA VSL Korea Co. Ltd. SEOUL Phone: +82 2 553 8200 Fax: +82 2 553 8255

MALAYSIA VSL Engineers (M) Sdn. Bhd. KUALA LUMPUR Phone: +603 7981 47 42 Fax: +603 7981 84 22

PHILIPPINES VSL Philippines Inc. PASIG CITY Phone/Fax: +632 723 13 95

SINGAPORE VSL Singapore Pte. Ltd. SINGAPORE Phone: +65 6559 12 22 Fax: +65 6257 77 51

TAIWAN VSL Taiwan Ltd. TAIPEI Phone: +886 2 2759 6819 Fax: +886 2 2759 6821

THAII AND VSL (Thailand) Co. Ltd. BANGKOK Phone: +66 2 679 76 15 - 19 Fax: +66 2 679 76 45

VIETNAM VSL Vietnam Ltd. HANOI Phone: +84 4 3976 5088

Ho Chi Minh City Phone: +84 8 810 6817 Fax: +84 8 810 6818

VSL Australia Pty. Ltd. NEW SOUTH WALES Phone: +61 2 9484 5944 Fax: +61 2 9875 3894

39

OUEENSLAND

Phone: +61 7 3265 64 00 Fax: +61 7 3265 75 34 VICTORIA Phone: +61 3 979 503 66 Fax: +61 3 979 505 47

SOUTH AUSTRALIA Phone: +61 8 8252 1900 Fax: +61 8 8252 1911

TASMANIA Phone: +61 3 6249 3044 Fax: +61 3 6249 3043

PERTH Phone: +61 8 9437 9575 Fax: +61 8 9875 3894

Fax: +84 4 3976 5089

Australia





www.vsl.com