VSL*news*

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VSoL® Retaining walls

FLEXIBLE SOLUTIONS

DIAPHRAGM WALLS

Low headroom challenges

SLIDING TECHNOLOGY

HK-Zhuhai-Macau immersed tunnel

SUSTAINABLE CONSTRUCTION 4


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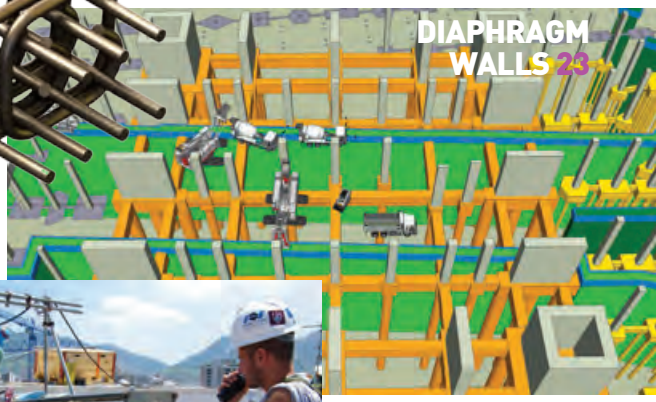
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Cover photo: Muscat Expressway, Oman

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Flexible solutions and innovation

Daniel Rigout, Chairman and Chief Executive Officer

Proposing innovative solutions, thinking outside of the box, providing one-off systems while always maintaining the highest levels of quality, safety and feasibility - this is at the heart of VSL's business model.

VSoL® retained earth walls combine reliability with ease of construction and offer customised solutions adapted to the client's requirements. Innovations in machines and their deployment in confined conditions have given Intrafor a competitive edge in the low-headroom environments frequently encountered in congested areas such as Hong Kong. A multipurpose anchorage for slabs and bridges, which can be used even in the thinnest slabs, provides a real alternative in the floor construction market. The highly challenging and technically demanding immersed tunnel project that will connect the bridges of the Hong Kong-Zhuhai-Macau link is another proof of VSL's innovative spirit in tackling the most challenging tasks.

As a leader in innovative construction techniques with a large network that is close to our clients, we listen and propose flexible solutions that are best for the project.

SAFETY MANAGEMENT

A safe working cycle for a safe work environment

VSL implements a 'safe working cycle' in its operations to help ensure that safety is at the forefront of everyone's attention. The system also helps to integrate safety-related actions into standard practice.

The VSL Safe Working Cycle forms a significant part of the frontline safety management system and is vital to excellent safety performance. There are however many other aspects to the system to cope with the highly technical and varied demands of the Group.

The safe working cycle requires that all members of the project organisation devote time and resources to safety, and encourages behaviour that reduces risk. The cycle is particularly focused on high-risk activities such as work at height or with machinery, temporary works, manual handling operations and addresses access.

Warm-up exercises The daily warm-up includes a set of standard stretches and aerobic exercises. The main purpose is to get everyone in the team to 'check-in' and start concentrating on being at work and part of the team. The exercises are usually led by a supervisor, though all members of the team are encouraged to volunteer to take the lead.

Work-start briefing Every day, the supervisor briefs his/her team at the start of the shift on exactly what activities will be carried out that day. The purpose is to ensure that everyone understands what they will be doing and what else will be going on around them. The briefing covers: main tasks, responsibilities, days program, materials and likely problems, and lasts about five minutes. It is usually conducted in the working area and may refer to drawings or other visual aids. During the briefing, the team has time to discuss the day's activities and how best to tackle them. Senior staff members attend briefings at least once a week.

Toolbox talks The safety supervisor, who is responsible for monitoring and driving the implementation of safety requirements on site, conducts a specific briefing once or twice per week. A health or safety topic is selected

that is particularly relevant to the ongoing work on site. The purpose is to explain or remind people about specific hazards and how to reduce the risk of injury. Topics could include: using particular equipment or tools (e.g. ladders or power tools); working around heavy machinery (e.g. cranes); weather-related issues (e.g. hot or

cold temperatures); actual accidents (e.g. from newspaper articles or internal alerts); or specific hazards (e.g. working at height or in excavations). The toolbox talks also give an opportunity for questions and discussion. Senior staff members attend to demonstrate their commitment to safety but also to learn themselves.

Task launch Whenever a new activity is about to start for the first time, a specific briefing is held to explain the new task in detail. Similar briefings are also carried out periodically if a task is ongoing for a long period. Holding the task launch briefing in advance of the start of work allows any outstanding issues to be resolved. During the discussion the team will review the working method, resources needed, time allowed, risk assessments, specific safety controls (such as 'permits to work') and safety equipment (e.g. personal protective equipment, barriers, lighting).

Permits to work Where 'permits to work' are required (e.g. for welding, gas cutting, confined space work, work over live traffic, excavation) a review is conducted in advance. The purpose is to ensure that all necessary controls for high-risk work are implemented and maintained, and that other people are aware that the activity is ongoing. If everything is satisfactory, a permit is issued to the person responsible for carrying out the work (e.g. the welder) who must then ensure that the requirements of the permit are adhered to throughout the operation (e.g. gas testing in confined spaces). The permit is returned to the issuer when the operation is completed, or when the permit expires.

Routine inspections Routine inspections are conducted in relation to specific equipment (e.g. lifting gear, cranes, fire-fighting kit, electrics, personal protective equipment, scaffolding) to confirm that they are in good order or identify defects and ensure they are addressed. Similar inspections are also carried out in relation to specific hazards (e.g. fall of people or objects, confined space, excavation). Responsibility for the inspection will vary depending on who is most appropriate. The frequency of inspections depends on the risk assessment and may for example be daily, weekly or monthly.

Housekeeping Maintaining a clean and tidy workplace is vital to helping avoid injuries and to good productivity and to VSL's image. Work teams are expected to keep their working areas as clean and tidy as practicable during the working shift to reduce the need for follow-on cleansing work. However it is usually still necessary to have an end-of-shift clean-up so that the working area is left in good condition for the next shift.

Maintenance VSL's operations rely heavily on specialised equipment. It is therefore essential that equipment is taken out of service regularly for thorough inspection and maintenance (e.g. parts replacements, greasing, cleaning). Regular maintenance also reduces the likelihood of breakdown and increases the lifespan of equipment.

Management inspections The senior members of staff responsible for a project or a particular working area conduct regular inspections to confirm compliance with requirements, identify any defects and problems and talk to the workforce. The senior personnel have the most experience of the operations and are also able to take a more independent view and identify any problems. Inspections are conducted weekly for construction works and monthly for permanent working locations such as workshops. Furthermore, the VSL Major Equipment Operation Permit launched in 2006 is compulsory since 2007 for the operation of all major equipment on VSL projects to improve safety and efficiency and enables a constant control by multiple operators on VSL's complex and usually one-of-a-kind equipment. This safe working cycle definitely ensures that safety-related actions become standard practice throughout VSL. ■

RUN FOR CHARITY

VSL Singapore's Friendship Run

As a corporate sponsor, VSL Singapore has contributed between $1,200 and $2,000 to a 5km charity run and 14 people from VSL joined hundreds of students to show their support. February's run, which was organised by Singapore Polytechnic's Business School Club, raised $10,000 for a Straits Times fund that provides pocket money for youngsters from low-income families. ■

VSL-INTRAFOR

Social events to boost camaraderie

For several years, VSL-Intrafor has taken part in the annual Stanley Dragon Boat Festival. Once the paddlers have finished their last race after six weeks of training, they head to a big boat hired by VSL-Intrafor for a well-deserved party. The special event is a great opportunity for bringing together local and expat staff as well as for meeting colleagues' families to build team spirit and camaraderie. ■

COMMUNITY ACTION

Speedy action to help victims of Typhoon Haiyan

VSL Philippines has taken rapid action to raise funds to show solidarity with the victims of the devastating Typhoon Haiyan, which happened in November 2013. With the help of his colleagues, family and friends, Bruno Vergnes has been carrying out a project to support the Filipinos of Visayas Island. He has coordinated donations amounting to €2,800 and chose to support the Negrense Volunteers for Change Foundation (NVC) as the most relevant local NGO. NVC's Peter Project is raising funds to replace boats destroyed by the typhoon with new ones costing about €400 each. The boats funded by the VSL team were handed over in February to local fishermen, who depend on fishing to feed their families. ■

BRIDGE CONSTRUCTION PARTNER

Quieter crossing

→ **Installation of a post-tensioned deck was chosen** as a quieter alternative than the traditional steel for a rail bridge crossing the Váh River in an urban area of Trenčín in Slovakia. The new bridge is being built as part of the upgrade of the Nové Mesto nad Váhom – Púchov railway. The project for Slovak Railways is being co-financed by EU funds and built by Bögl and Krýsl to a design by Betoning. The seven-span viaduct is 340m long and is being constructed by the balanced cantilever method. VSL is supplying tie bars and post-tensioning, together with PT-Plus® ducting. ■

facts & trends

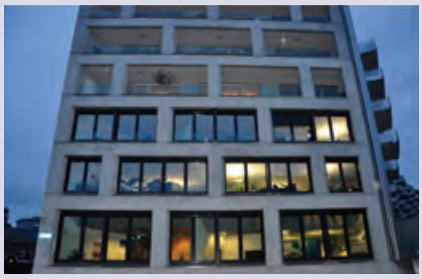
Brunei
MFT debut

→ **Construction of the Berakas Flyover marks VSL Brunei's first use of modular form-traveller equipment** to construct a bridge deck. The project involves building a 140m-long dual-carriageway bridge, designed as a cast-in-situ segmental structure constructed using the balanced cantilever method. It has three spans, made up of a 70m main span with two side spans of 35m. Typical cycles of six days per pair of segments are regularly achieved. ■

Slovakia
Building success

→ **VSL Systems /CZ/ has completed its first major post-tensioned building project in Slovakia.** The contract involved supply and installation of nearly 100t of bonded slab and multi-strand post-tensioning for the 120,000m² first stage of the Bory Mall commercial and entertainment centre in Bratislava. Execution of the work was demanding due to the complexity of the structure and the short schedule. The project's investor is Penta, the main contractor is Váhostav and structural design was by the Helika and PPP design offices. ■

Switzerland
Reinforcement



→ Additional steel columns have been installed by VSL into the first three floors of Fribourg's Les Galeries du Rex in what is the first application of its kind in Switzerland. The building had to undergo rehabilitation work as cracks had appeared in the beams of the façade. VSL's reinforcement solution uses an enhanced bracing system to strengthen the structure while limiting the transmission of forces on the upper floors. Benefits of the system include its ability to increase the lateral stiffness of the structure, improve earthquake resilience and be integrated into irregular building layouts while reducing beam and column sizes. ■

Certification
ISO for FT Laboratories

→ **FT Laboratories is proud to have become Hong Kong's first provider** of construction laboratory testing to achieve ISO/IEC 27001:2005 certification. Award of the certification demonstrates that customers can be assured that their sensitive information and data are properly secured. The success of IT systems relies on whether information security has been properly addressed. ISO/IEC 27001:2005 is an internationally recognised standard for information management. This independent framework provides a managed approach to evaluate, implement and maintain data security at the highest level. ■

DNV

DNV BUSINESS ASSURANCE
MANAGEMENT SYSTEM CERTIFICATE

FT Laboratories Ltd.

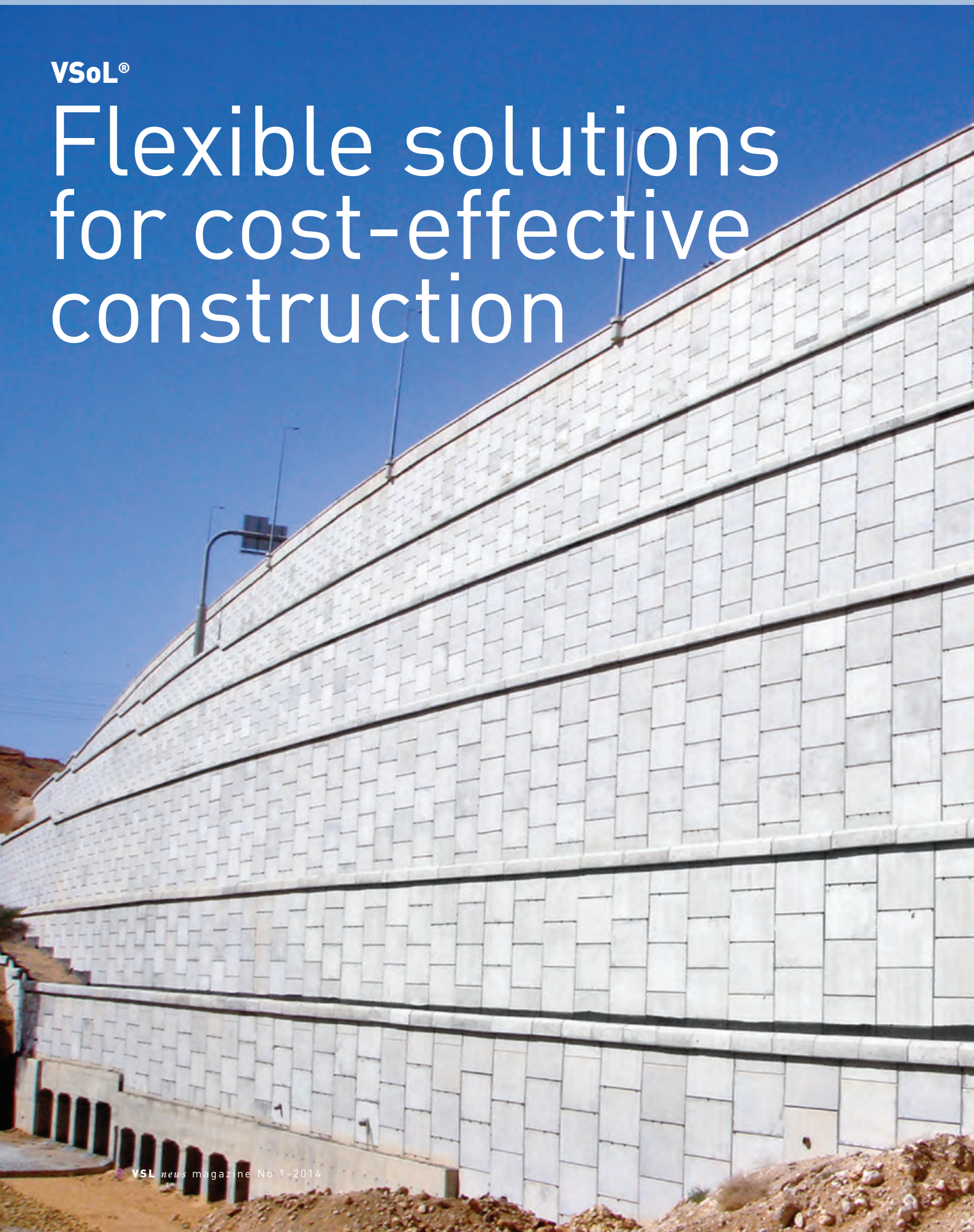
ISO/IEC 27001:2005

Innovative design
Pile-eating solution

→ **The design team at Intrafor has developed an innovative 'pile-eating' solution** that will be used in building a 220m-long diaphragm wall for the five-storey basement of an office building in Kwun Tong. The project is Intrafor's second contract for Sun Hai Kai Properties, one of Hong Kong's largest developers. The biggest constraint before work can start on the wall comes from the existing foundations. Intrafor will first cut through the 1.5m-thick pile caps along the wall's alignment. The existing piles will then be removed using a specially made chisel developed by Intrafor to cut and 'eat' the piles as it excavates. ■

VSoL®

Flexible solutions for cost-effective construction



Use of VSoL® is increasingly popular as a revolutionary technique in the field of retained earth construction for walls and bridge abutments: it combines reliability with ease of construction to provide customised solutions adapted to the client's technical and architectural requirements.

Record-breaking 65m-high VSoL® wall on the Southern Expressway in Muscat, Oman

cover story

VSoL®

VSoL® is a cost-effective, high-performance retaining wall system that has proven its excellence in a wide variety of applications. Since its development in the early 1980s, the system has been used extensively worldwide to provide economical and aesthetically appealing retaining wall solutions for infrastructure. The system is used for projects ranging from general grade-separation retaining walls to highway bridge abutments and mining structures. In addition to its other benefits, the system is very easy and rapid to install, as it has only three primary components: soil, reinforcement and facings. The use of factory-produced elements combined with simple erection methods in a high-quality finish. Finally cost savings of up to 50% can be secured compared to traditional wall systems, thanks to the efficiency of the model using the soil as a primary structural component.

Unlimited applications

The VSoL® wall system meets the requirements of projects in both the private and public sectors. Owners, engineers and contractors worldwide make use of VSoL® for the construction of many types of temporary or permanent structures. VSoL® can cope with various backfill soils and foundation conditions. Straight, curved, tiered, superimposed or back-to-back walls can be all catered for. VSoL® can be used on urban, marine, mountainous and flood-prone sites thanks to its design flexibility. The various VSoL® solutions all share the same advantages including a long service life due to the use of reliable and durable materials; considerable savings in both construction time and material costs; aesthetically pleasing structures that blend with the environment.

Copying nature: VSoL® blends in with the natural surroundings
The visual appearance of the 9,250m² of concrete facings for the Thonon-les-Bains Bypass in France mimics the local natural rock strata. As well as blending in visually, it was essential to preserve the local ecosystem while ensuring the overall stability of slopes above the river. The VSoL® solution of four cascading walls has met all the aims, with the facings made using five different carved rock moulds.

Easy installation...

VSoL® walls require reduced quantities of steel reinforcement and concrete compared with traditional wall systems and generally allow the reuse of local materials for the backfill. The simple and rapid installation is carried out using conventional equipment, which is another factor in making the solution very cost-effective. Typically, savings range between 20% and 50% depending on the wall heights, site conditions and local prices.

...for a long service life

The wall design can give a design life of up to 120 years. Concrete facings are very durable and require little maintenance, the reinforcement for the steel option is made of customised mesh, generally galvanised and members are designed to allow for the anticipated sacrificial loss over the wall's life . The polymeric strips for the non metallic option are fully tested in a range of environments to provide

> *"The VSoL® wall system resists the high forces arising from seismic activities."*

long-term durability. The fill making the last structural member of the wall shall comply with specifications taking into account mechanical, chemical and electrical properties, these are however such that most of the local fill can be accommodated for the wall construction.

Seismic performance

VSoL® walls are strong, yet flexible enough to resist the high forces and movements arising from seismic activities. During an earthquake, the seismic forces are dissipated by friction between the reinforcement and the fill. Inherent ductility and resilience, coupled with the proven seismic performance of VSoL® walls, justify their high degree of adoption in seismically active regions. VSoL® walls are designed to be internally stable and externally reinforced soil structures. They remain however flexible and so are more accommodating to settlement than most other forms of wall construction. The use of flexible reinforcement connections and settlement-tolerant facing details means that VSoL® walls can be built on sites with poorer foundation soils than conventional walls, without affecting the structural integrity and performance of the finished structure.

After an earthquake in Chile: the VSoL® wall still standing strong, while the bridge collapsed

VSoL® applications

Bridge abutments

VSoL® walls frequently serve as bridge abutments, directly supporting the transition slab and the bridge deck. This avoids the need for deep foundations and costly abutment support structures. Where piled bridge supports are required, VSoL® walls can be incorporated into the design to provide abutment face and wing walls, with the bridge support columns located either in front of the VSoL® panel facing or behind it within the block of reinforced fill.

Retaining walls

For projects such as highways and railways where the retaining walls need to bear heavy loads, the VSoL® wall solution can provide savings of up to 50% compared to the costs of conventional walls. This is particularly the case when the structure is founded on poor soil, which would otherwise require ground treatment or deep foundations. VSoL® systems can also be used for protection against landslides, avalanches, floods, fire, blast and earthquakes.

Mining applications

VSoL® structures are ideally suited to many industrial applications thanks to their capacity to withstand vibrations, impact, explosions, flooding and heavy loading. VSoL® walls are also easy to remove, which can be an important factor as these types of structures are generally only temporary.

Any size, colour or shape

The VSoL® wall system's concrete facings can accommodate many shapes, patterns and textures. In addition, the concrete can be coloured to match the natural surroundings or to meet any specific architectural requirements. Raised relief, sandblasted, exposed aggregate and conventional smooth facings represent just a few of the standard VSoL® finishes that are available.

VSoL®: how it works

Backfill

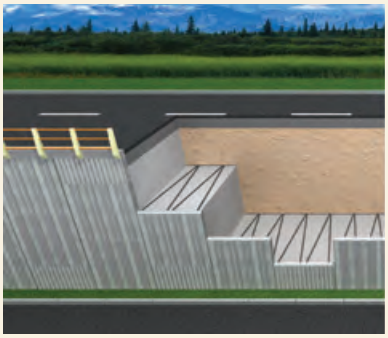
The reinforced fill material in a VSoL® wall is chosen to meet system requirements and project specifications. Such requirements cover gradation, shear strength, density, pH and electrochemical properties. VSoL® walls are often built using fill materials sourced on the site, making them an even more cost-efficient and environmentally friendly solution.

Reinforcement

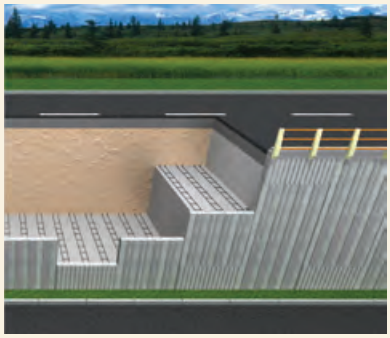
The reinforcing elements are either steel 'ladders' or polymeric VStrips. The reinforcing elements tie the facings into the soil mass and resist the forces generated within the wall. The reinforcement develops a high soil-to-reinforcement interaction and pull-out resistance, ensuring stability, excellent alignment and reliable performance.

Facings

Facings are the structural elements that retain and confine the backfill material. They are tied to the fill by the mesh ladders or VStrips. Almost unlimited alternatives are available: the facings can be concrete of different shapes, textures and colours; steel mesh, which may be filled with rock for a natural stone finish; or even 'green' surfaces incorporating vegetation mats to allow the vegetation to grow over the wall.



VStrip reinforcement



Steel mesh reinforcement

Wood solution for a pleasant look of the retaining wall.

Innovative reinforcement

The use of polymeric VStrip reinforcement increases the versatility of the VSoL® wall system. One of the major advantages is that the use of polymeric components ensures long-term durability in aggressive environments. VSoL® VStrips are made from polyester yarn, extruded inside a polyethylene shell, which is designed to enhance the friction with the surrounding soil and ensure the high durability of the strip. To ensure full load transfer in the VSoL® Polymeric wall system, VSL developed an innovative solution to connect VStrip reinforcement to concrete facings.

Create simple connections

The connection is simply a U-shaped internal slot created at the rear of the concrete facing by introducing a reusable void former during concreting. The VStrip can be inserted through the connection during installation, eliminating the need for any additional cast-in items. The reusable void former is either made from steel, aluminium or plastic and consists of two halves that are cast into the concrete. The void former has a curved wedge shape that enables the core beam to be as deep as possible while keeping the width of the recess as small as possible. Once the concrete has set sufficiently, the void formers and its supporting system can be removed. This can normally be done when the side forms of the panel are stripped. The formed void has sufficient space for strip insertion and the underside of the core beam is smooth with no sharp edges.

Proven performance

The VSoL® steel system's reinforcing mesh ladders develop the greatest soil-to-reinforcement interaction and pull-out resistance of any reinforced retaining wall system. The ladders are composed of longitudinal and transverse wires, welded together in a way that guarantees optimum load transfer. They are generally galvanised to enhance durability. The connection to the wall facing is simple and effective.

Minimising the visual impact of the concrete walls in an area with "black" soil and vegetation. VSL provided 6000m² of colored panels with pigmented concrete for the Variante de Canjayar project in Almería, Spain

Simple and rapid installation

The simplicity of the installation method and rapid connection of the reinforcement ensure cost-effective wall construction. Installation is normally undertaken using a three-man crew working with a small or truck-mounted crane and conventional earthmoving and compaction plant. Work is generally carried out entirely from the rear of the wall, which permits ease of construction on restricted sites.

VSoL® wall construction can proceed rapidly, with productivity usually dictated by the schedule of fill delivery and placement.

Maximum economy in an arch

VSL offers a precast concrete arch system suitable for a variety of structures. The VSL-BEBO® Arch system is a pre-engineered solution to create arches with spans from 3.5m up to 31m. The arches are made up of precast segments.

The arch sections are slender in design. Concrete and reinforcement savings can reach up to 50% compared to traditional approaches. The requirements for fill material are also moderate. Further savings in materials and maintenance can be achieved since there are no bridge bearings, joints or transition slabs.

The construction of a precast arch structure is simple, rapid and reliable, requiring only conventional equipment and just a small crew. VSoL® walls can be combined with VSL-BEBO® Arch solutions to create cost-effective, low-maintenance aesthetically pleasing bridges as well as drainage culverts. The combination of the VSL-BEBO® Arch system and VSoL® spandrel walls provides a sustainable and energy- efficient alternative to traditional designs for small- to medium-span bridges. VSL provides design, casting and installation services for arch projects, using elliptical, circular or flat arch profiles to suit project requirements. Arch applications include overpasses, bridges, tunnels, culverts and underpasses as well as other structures.

Temporary walls to support heavy loads
VSoL® walls are particularly suitable for applications requiring the temporary support of heavy loads such as the world's largest mobile crane, as used at the site of the new European Pressurised Reactor (EPR) nuclear facility in Flamanville, France. A number of temporary retaining walls were built and raised at the same time as other adjacent permanent structures to create temporary working platforms on the congested site. Initially the walls were to be built using conventional prefabricated concrete methods but VSL's alternative VSoL® wall solution enabled the tight programme to be met.

VSL's precast or cast-in-situ concrete arch solutions deliver the maximum economy and are carefully tailored to suit the structural and geometrical requirements of each project. Standard geometries and designs cover most applications but bespoke solutions can be developed rapidly if required. The VSL-BEBO® Arch system can accommodate high depths of fill, large live loads and the heavy loading conditions often associated with mining applications. The arches can be installed quickly and safely over existing roads and live rail or other services with minimal disruption.

VSL-BEBO® structures are generally built from a number of precast reinforced concrete arch elements placed on cast-in-situ or precast footings, piers and/or abutments. After installation, these elements are backfilled and covered with well-compacted earth fill. The reinforced concrete arches have a thickness that is sufficient to provide substantial sectional capacity, but small enough to allow elastic deformations that mobilise part of the passive resistance of the backfill. The backfill not only provides the bed for the road surface but also increases the load-carrying capacity of the structure. The arch system is the ideal structural shape to carry vertical loads over a given span and is therefore a naturally 'energy-efficient' construction technique.

Dismantling, salvage and remediation of VSL-BEBO® Arch structures at the end of their life is easy and environmentally friendly as the precast elements can be removed and transported off site. The main items to be maintained regularly on traditional bridges are the bearings and expansion joints. Precast arch bridges avoid them. There is no movement joint and the deck of the bridge is of compacted earth fill, which provides excellent protection for the precast arch segments.

Plain grey facing panels
VSL Australia was recently awarded the design and supply of 1,037m2 of VSoL® retained earth walls up to 9.8m high for the Telegraph Road open level crossing replacement project. The bridge project uses 2m by 2m plain grey facing panels. The abutments had an added design feature in the form of dead-man anchors to provide abutment restraint and were in the form of buried precast panels, attached with threaded galvanized bars.

Built to high standards

VSL has developed Cybèle, a software that automates the design of VSoL® walls, regardless of project geometry. All VSoL® walls are designed and built in accordance with the latest standards, including:

- AASHTO - LRFD US specifications for highway bridges
- BS 8006 - UK code of practice for strengthened reinforced soils and other fills
- NF P94-270 - French national standard
- GeoGuide 6 - Hong Kong
- AS 4678/RTA R57 - Australian standards

> *"VSL-BEBO® arches are cost-effective and require minimum maintenance."*

Better life with VSoL® solutions

Material savings in concrete and steel in comparison to traditional wall systems can range from 20% to 50%, depending on the wall height and the loads applied. VSoL® walls take advantage of the soil strength and weight in the reinforced block, acting as a gravity wall.

The combination of thin facings and site-won backfill as primary structural elements makes VSoL® walls very efficient in terms of material use. This dramatically reduces the need for concrete and rebar and therefore reduces the overall CO_2 footprint of the construction project by up to 60% compared to a conventional wall structure.

Very resilient structures requiring little maintenance

The durable walls need little maintenance during their life and also exhibit excellent resilience to exceptional events such as flooding, earthquake and explosions.

VSoL® walls are easy to build and similarly easy to dismantle. They do not produce large amounts of unusable waste materials. The fill materials can be reused directly or in other walls, while facing elements can be reused or recycled into aggregates for walls, roads or other construction uses.

Versatile and economical solutions for its different applications make the VSoL® the system of choice. ■

"Up to 60% reduction in the CO_2 footprint"

BEBO in use on Clyst Honiton Bypass
VSL-BEBO® Arches and VSoL® walls have been used to create an 80m-long tunnel that passes under Exeter Airport's runway and has been constructed to meet aviation safety standards. The tunnel is part of the Clyst Honiton Bypass, which connects the A30 from the Exeter airport junction to the B3174 'London Road' and will keep heavy traffic off smaller local routes around the village.

T-shape panels in marine environment.

site insights

Stay cables
Challenging stays

→ **VSL has carried out a wide range of work** for a pair of cable-stayed bridges at Rokan Hilir on Sumatra Island in Indonesia. Both bridges have four pylons supporting three 111m long main spans, flanked by side spans of 63.4m. Construction of the deck was by underslung form-traveller, supported at front with a pair of permanent stays. VSL developed and supplied the anchor system allowing load transfer of stay forces from the traveler to the completed segment. VSL's scope included post-tensioning work, supply and installation of the stay cables and checking and operation of the traveler. Tidal ranges of up to 5m and strong currents were among the project's key challenges. ■ **Contact: info@vsl.com**

Post-tensioning for buildings
Improved competitiveness

→ **The VSlab system has provided a very competitive solution** for the Sunrise City project in Ho Chi Minh City, Vietnam. Sunrise City is developer Novaland's first project to use post-tensioning. VSL worked with the developer and its consultant throughout the design stage. Building the four 33-storey towers has required 94,400m^2 of post-tensioned flat slabs. VSL installed the VSlab to a six-day typical cycle. Use of VSlab gave an efficient floor design, eased installation and minimised the manpower required. ■ **Contact: info@vsl.com**

Stay cables
Second crossing

The work by VSL on one of Perú's first cable-stayed road bridges, the Bellavista Bridge, has now been followed by a contract to supply and install the cables for a similar project. The new Comuneros Bridge over the Mantaro River has total length of 300m with a 160m main span. Its steel deck is supported from two H-shaped concrete pylons by a total of 48 stays. The VSL SSI System is being used in a range of anchorage sizes. ■ **Contact: info@vsl.com**

PT for bridges
Abidjan's third bridge progress

→ **Precasting for a major viaduct in Abidjan, Ivory Coast, is almost complete**, with weekly production for the city's third bridge running at three full caissons. In-situ work at the Valéry Giscard d'Estaing interchange is also progressing fast with completion expected in July. VSL is supplying all post-tensioning materials including 1,100t of strands and more than 2,100 anchorages, as well as providing equipment and technical assistance at the casting yard and the Valéry Giscard d'Estaing site. ■ **Contact: info@vsl.com**

Stay cables
Record breaker

→ **VSL has been appointed to install 736 sets of anchorages** and 3,250t of stay cables for one of the largest concrete bridges under construction in China today. Substructure construction of the four-pylon cable-stayed Chi Shi Bridge in Hunan Province began in March 2010. Programme of the works is key to the project's success, and VSL's performance to date has ensured that the stay installation has remained well in line with the head contractor's deck construction cycle. The project is owned by Hunan Expressway Construction & Development Group and the consultant is China Railway Major Bridge Reconnaissance & Design Institute. ■ **Contact: info@vsl.com**

PT for bridges
Peruvian link

→ **Work has started on the Chilina Bridge** as part of a new road link in Arequipa, Perú. The 560m-long bridge has four piers and twin decks and is being cast-in-situ by the balanced cantilever method with form-travellers. VSL, through its licensee SEC Peru, is supplying and installing the post-tensioning. ■ **Contact: info@vsl.com**

Stay cables
Java landmark

Courtesy of Public Work Department of Republic of Indonesia

→ **A new landmark cable-stayed bridge** with an inclined pylon has been built on the approach to Solo City in Central Java, Indonesia. VSL's subcontract for the Solo Kertosono interchange bridge included post-tensioning work as well as supply and installation of up to 112m-long stays from the SSI Stay Cable System. The 41.5m-high pylon is inclined at 27° and stay installation began when concreting reached 28m above deck level. During construction, two of the stays provided temporary support for the pylon. ■ **Contact: info@vsl.com**

PT for buildings
Challenging transformation

→ **VSL has completed the challenging first phase of work** to transform the historic Sant Antoni marketplace in Barcelona. A new 12,000m² joint-free voided transfer slab post-tensioned in both directions was built below the old building to support it during the construction of three underground levels underneath. Spans of 30m by 20m combined with design loads of 24kN/ m² and the need to retain the existing steel structure meant that the Sacyr-Scrinser-Copcisa JV and VSL had to develop a tailor-made solution. Phase 2 will see VSL working on the PT slabs for the new underground levels. ■ **Contact: info@vsl.com**

Heavy lifting
Abu Dhabi landmark

→ **VSL has set a new record** with its 335m high lifts of trusses for Abu Dhabi National Oil Company's new headquarters. The 74-storey tower stands 342m high, which makes it the tallest landmark in Abu Dhabi. VSL was awarded the contract to lift and slide three roof trusses, each weighing 360t. The trusses were placed on temporary movable frames and positioned using a method specifically developed for the project. It took three operations, with a final slide of up to 32m, to move each truss into its final position between the two core walls. ■ **Contact: info@vsl.com**

Heavy lifting
Launching a walkway

→ **In El Tranqueru, Spain, difficult access from only one side** meant that a special approach was required to recover a 45m-long walkway that had slipped into the sea because of earth movement. VSL supported the designer in the development of a method to launch the 25t steel structure, the VSL skidding system was used to move it 50m to the opposite abutment. A 25t rear 'nose' was added to the bridge, which was counterbalanced by up to 110t during the launching operation. Finally, the structure was lowered onto its permanent bearings. ■ **Contact: info@vsl.com**

PT for slabs on ground
Six-week slab

→ **VSL was appointed to design and construct** approximately 12,000m^2 of post-tensioned slab on ground for the Linfox's container terminal, Australia. The entire pavement was installed in seven pours and completed in just six weeks. The post-tensioned solution system was chosen by Linfox, the facility operator, because of its competitive cost, quick construction schedule and low maintenance requirements. It can support 25t containers stacked four high and 100t axle loads from forklifts. ■ **Contact: info@vsl.com**

PT for slabs on ground

Cool design

→ **The new slabs on ground for a freezer and cool-room project in Victoria, Australia** have been designed to accommodate a wide range of temperatures, from -22°C to 15°C. VSL's third contract at the food storage facility involved the design and construction of 7,000m² of slabs on ground to support heavy static and automated racking loads. The post-tensioned slabs have been designed without joints to avoid damage caused by freezing water. In addition, the use of jointless slabs minimises the ingress of dirt, helping maintain a hygienic environment, and mitigates the future maintenance work, the joints being generally weak points. ■ **Contact: info@vsl.com**

Heavy lifting

Power lift

→ **The 450MW Tufanbeyli lignite-fired thermal power plant,** located in Turkey's Adana region, is expected to go into service in 2015. The project also includes the operation of the mine, which will provide the fuel. VSL was appointed for the 57m lifting of two steam drums, each weighing 160t. The installation was completed at the end of 2013. ■ **Contact: info@vsl.com**

Post-tensioning for bridges

Rainy-season challenge

→ **Challenging ground conditions in the rainy season** meant that extra care and preparation were needed for VSL's launch of the K4 Bridge at a major housing development south of Manila, Philippines. VSL was appointed by MDC to prefabricate the bridge's 30m-long, 45t I-girders. The contract also included to place the beams by a pair of mobile cranes. VSL Hong Kong provided technical supervision for the project, which was completed as planned in October 2013. ■ **Contact: info@vsl.com**

Heavy lifting

Controlled deformation

→ **Japan Tobacco International's new nine-storey headquarters** in Geneva, Switzerland will be a landmark structure featuring striking cantilevers at its north and south corners. The exceptional architecture required careful deformation of the structural steel in order to install the glass façade safely. VSL applied a 1,000t force at four points to provide the required structural deformation needed to install the 700t of glass. The risk of breaking the glass during installation would have been too high without the controlled deformation. ■ **Contact: info@vsl.com**

Bridge construction
HZMB update

The first pair of precast shells for the pile caps of the Hong Kong-Zhuhai-Macau Bridge (HZMB) was installed in December with a 300t floating crane. The shells, fabricated in China, weighed 210t, making a total lift load of 230t with the support system and access walkway. They were the first in a long series of 148 shells that will be installed. The support system has been designed to avoid high-risk diving works. Temporary support beams are clamped to the shell walls with VSL Stress bars and rest on king posts until the concrete stitch between the shell and pile head reaches 30MPa. The shell is then ready for internal pile cap works. ■ **Contact: info@vsl.com**

Seismic protection
Vibration mitigation

VSL has designed, supplied and is installing the VSL-R damper system for a 25-storey residential building in Kaohsiung City, Taiwan. In total, 52 sets of VSL-R dampers are being installed from the 2nd to the 14th floors to mitigate wind- and seismic-induced vibrations and deformations. The project uses high wall-type units each containing a VSL-R damper. They are integrated into prefabricated steel panels and installed directly into the structure during construction. ■ **Contact: info@vsl.com**

Bridge construction
Second time at Ballina

VSL has recently been awarded a contract to construct the second bridge over Emigrant Creek South in Ballina, Australia, for Leighton Contractors. The 3 span bridge, which has an 80m main span, is part of the ongoing Pacific Highway Upgrade for Roads & Maritime Services, New South Wales. Construction will be by the cast-in-situ balanced cantilever method using VSL modular form-travellers. VSL won the contract thanks to its expertise and to its good working relationship with Leighton on the successful first Ballina crossing in 2009/2010. ■ **Contact: info@vsl.com**

PT for bridges

Multi-span PT

→ **More than 500t of VSL post-tensioning composed of several systems are being installed** for a flyover being built as part of the R35 expressway near Hradec Kralove in the Czech Republic. A consortium of Skanska and Metrostav is building the bridge to a design by Pragoprojekt. VSL is supplying the post-tensioning system used in Metrostav's construction of the 1,001m long left bridge and the 266m long associated ramp. The multi-span concrete viaduct has a span length of up to 61m. ■ **Contact: info@vsl.com**

Repair & strengthening

At the top of Europe

→ **Located** in a stunning setting on top of the Jungfraujoch high in the Bernese Alps at 3,454m of altitude, the restaurant's roof needed reinforcement. VSL has been awarded the contract for the removal and replacement of post-tensioning. Part of the works had to be executed during the night to ensure the least possible disturbance to tourists. Particular challenges for VSL's specialists on site came from working at a height of almost 3,500m in temperatures that were as low as -5°C at the external anchorage locations. ■ **Contact: info@vsl.com**

Repair & strengthening

Complex code compliance

Ziegler Cooper architects

→ **The parking structure at the Park Plaza Complex in Austin, Texas,** was a few inches too tall to meet the latest building code. VSL was appointed to remove the heavily post-tensioned deck slab to bring the structure into compliance with the code. As part of the scope, VSL de-tensioned the post-tensioning for the 5th-floor deck, removed and recycled the concrete and removed a wall. All concrete was tracked and recycled to help the general contractor obtain LEED Silver rating. ■ **Contact: info@vsl.com**


Image source: BVN

Infrastructure protection

New Australian Embassy

→ **Bouygues Thai-VSL Australia (BVSL) has signed a significant contract with the Australian Government** through the Overseas Property Office of the Department of Foreign Affairs & Trade. BVSL will construct the new Australian Embassy Complex in Bangkok, with VSL Thailand delivering the post-tensioning works. VSL Infrastructure Protection is to provide physical security integration services for blast and intruder resistant specific works. During the execution of the project, VSL Australia will be a joint-venture partner of Bouygues Thai, and will provide key staff in the project team. ■ **Contact: info@vsl.com**

Joints

Ring around São Paulo

→ **VSL is installing more than 9,000m of joints** on the east section of the Rodoanel Mario Covas ring road, which is one of the most important transport projects under way in São Paulo. The works will be completed in just three months. ■ **Contact: info@vsl.com**

Structural design

DC digesters

→ **VSL is celebrating successful completion of four digester tanks for Washington / DC Water in the USA.** The digesters are the centrepiece of a design-build project carried out by a JV between PC Construction and CDM Smith. The tanks are just over 30m in diameter, with walls that are 22.5m in height and 380mm thick. VSL post-tensioning was chosen as it guaranteed a 'bottle tight' structure and allowed for thinner

walls using less rebar. The bonded system provided bi-axial residual compression to eliminate cracking. Other aspects contributing to the project's success included the use of a jump-form system together with self-consolidating concrete, which ensured an excellent surface finish and prevented voids. ■ **Contact: info@vsl.com**

PT for LNG containments

Stringent quality specs

→ **VSL has proved itself highly adaptable in carrying out simultaneous construction** of three identical 190,000m³ storage tanks while meeting stringent quality and safety requirements. The project at Dunkerque LNG terminal, in Northern France, is nearing completion and has involved over 86km of ducting, 372 U-shaped 40m-high vertical cables, 384 semi-circular 150m horizontal cables, 1,680t of strands, 580t of cement plus anchorages. EDF's terminal will handle about 20% of France and Belgium's annual gas consumption. ■ **Contact: info@vsl.com**

Ground anchors

Innovative alternative

→ **An innovative design by VSL has solved constructability issues** for the contractor building the Headland Park project in New South Wales, Australia. Baulderstone (now Lend Lease) won the construction contract for the waterfront project, which includes creation of a cove and a naturalistic shoreline. VSL provided an alternative approach for the supply and installation of 23 permanent anchors to support a counterfort wall, using reaction blocks and AF anchorages. Benefits included allowing backfill to start earlier and to be placed to a higher level before anchoring works would begin. VSL's design also simplified the load-testing of the anchors. ■ **Contact: info@vsl.com**

Deconstruction

Airport ramp removal

→ **Fort Lauderdale Airport, in the US required the removal of a three-span precast segmental box** girder bridge. The bridge's main span crossed five active rail tracks and one of the back spans was situated over a three-lane access road for the airport. VSL developed a staged demolition plan that avoided disruptions to the traffic below. In addition, VSL provided modifications to the existing post-tensioning to enable segmental removal. ■ **Contact: info@vsl.com**

PT for LNG containments

Full-scope construction

→ **On April 8th 2014, VSL Thailand and VSL Offshore,** working together in Joint Venture, secured the complete civil works sub contract for the construction of two 160,000m³ elevated outer concrete LNG containment structures with IHI Corporation of Japan. The works associated with the PTTLNG Phase 2 LNG Receiving Terminal Expansion Project are located in Map Ta Phut, approximately 2 hours from Bangkok, Thailand.

VSL scope of works includes excavation, pile cut off, column extension, backfill, compaction, ground pavement, elevated base slab, walls, ring beam and roof construction; and also the supply and installation of movement joints, monitoring system and post-tensioning. VSL shall be providing and operating all major plant such as tower cranes, concrete placing equipment, formwork and access. VSL shall be responsible for the cut, bend, and fix of reinforcement and placing of concrete works. ■ **Contact: info@vsl.com**

Monitoring

Matterhorn monitoring

→ **VSL has installed new cells** to monitor the 35-year-old anchors that support the upper station of the cable car on the Klein Matterhorn in Switzerland. Site-specific challenges came from the temperatures of -11°C, the 3,800m altitude and also from the fact that the cable car remained in service throughout. In addition, the measuring cells had to be installed without de-tensioning the 14 anchors. The work was carried out in collaboration with Geoprevent AG to allow the client to access the monitoring system online. ■ **Contact: info@vsl.com**

Ground engineering

Rock challenge

→ **Intrafor is completing a project to extend Diamond Hill station** into an interchange between the Shatin to Central and Kwun Tong lines in Hong Kong. The works comprise a 373m-long diaphragm wall and six barrettes to provide the permanent structural wall and support for the station. The project's biggest challenge has come from the need to excavate 50% more rock than expected. Fissure grouting and shear pinning are being implemented where necessary and barrettes are being built to support the adit between the new and old stations. At peak, the project involved three hydromill cutters and six excavation cranes. ■ **Contact: info@vsl.com**

Ground engineering

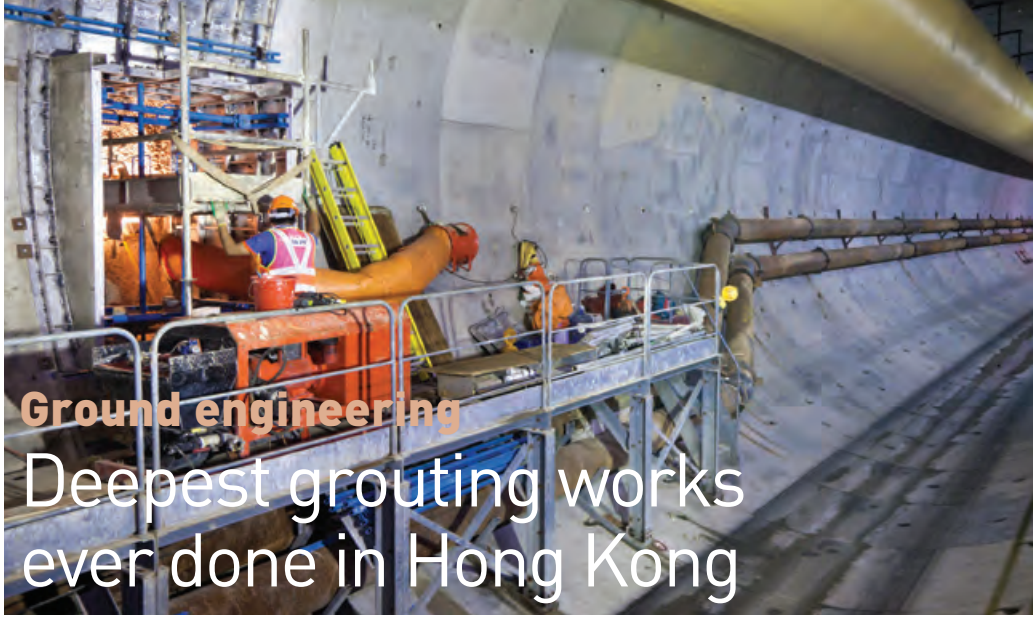
Fast-track excavation

→ **Intrafor's excavating know-how** and its commitment of meeting tight deadlines were critical to winning a contract for the basement of a 7,887m² multi-purpose development. Ocean Century Industrial Ltd's development on the waterfront of Hong Kong's North Point will feature a hotel, residential area and a public open space integrated with the promenade. Intrafor specialists are using two hydromill cutters, four excavation cranes to construct a 343m-long diaphragm wall embedded into rock. The volume excavated is set to reach about 13,000m³ and work was completed in May 2014. ■ **Contact: info@vsl.com**

Ground engineering

Macau expansion

→ **A challenging project to build a 560m-long diaphragm wall** in old reclaimed land has just begun in Macau's Cotai area. Intrafor is responsible for the construction of a basement retaining wall for SJM Holding's latest venture, a luxury hotel and casino complex. A particular technical difficulty in building the 40m-deep wall is not knowing exactly how the site's soil, including a mix of fill, overlaying marine deposits, alluvium, CDG and granite will behave during excavation, although no ground treatment is currently anticipated. ■ **Contact: info@vsl.com**



Ground engineering

Deepest grouting works ever done in Hong Kong

→ **Construction of a diaphragm wall and ground treatment works** on the Express Railway Link (XRL) are progressing well. The XRL is a high-speed train link that will connect Hong Kong to Shenzhen and Guangzhou, dramatically reducing journey times. Intrafor is completing works along two 3.5km parallel single-track tunnels, which will be excavated using a tunnel boring machine (TBM).

To accelerate construction and launching of the TBM, the shaft's retaining wall was built on bedrock, leading to several challenges. In areas with high rock density, the bulk excavation had to be taken beyond the toe of the panel. A waterproofing grout curtain and shear pins had to be added to increase stability and avoid water seepage. One side of the wall was built along a 20m seawall, which meant void filling and grouting were needed to avoid the risk of collapse. The TBM had to come within 0.5m of 6 existing buildings and needed to cut through an existing sump pit attached to the live line. Combined with ground instability associated with the construction of 12 cross-passages, and an existing convergence zone between the two tunnels, this project had multiple layers of complexity and required expert ground improvement measures. ■ **Contact: info@vsl.com**

Ground engineering

Express jacking

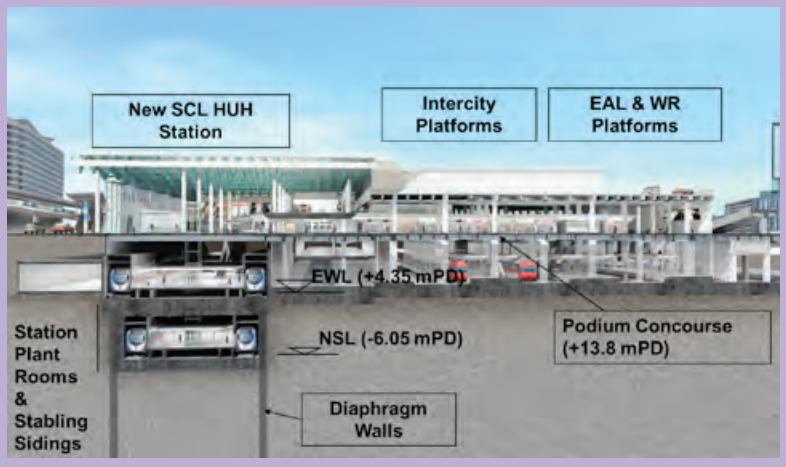
→ **Hong Kong's first box-jacking operation will be carried out by Intrafor,** which will place two tunnels directly underneath the live Airport Express railway (AEL). The tunnels are approximately 14m in height, 23m wide and 70m long, requiring a total excavation of 35,000m^3. Intrafor is currently carrying out the ground improvement works underneath the AEL abutment, using eight percussive rigs to drill 2,500 holes for the installation of 65km of TAM (tube a manchette) pipe. Injection of some 17,000m^3 of grout into the ground will improve the soil properties for the future box-jacking activities. Work should be complete by early 2016. ■ **Contact: info@vsl.com**

DIAPHRAGM WALLS

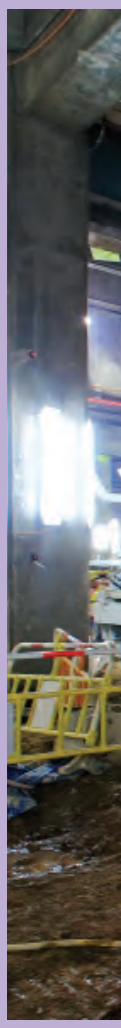
High expectations with low headroom

Intrafor has recently brought its expertise to low-headroom projects with technically demanding ground conditions, and is one of the very first companies to use the latest generation low-headroom CBC25 cutter...

In today's busy cities, it is rare to build underground on a clear plot of land. Knowing how to design excavations in complex site environments around and below existing neighbours - be they live metro lines, foundations, utilities or even a concert hall - has rapidly become an Intrafor trade mark. Intrafor's design team works together with clients to find the best concepts for a project from the outset, encouraging early involvement of all parties. Recently, Intrafor has brought its expertise to low-headroom projects involving technically demanding ground conditions.



Intrafor Hong Kong is building a 450m-long diaphragm wall, equivalent in size to five football pitches, under an existing train station concourse and concert hall with vertical clearance as little as 5.5m. It is the first time a project of this size has been carried out entirely underground. The finished structure will house a double-deck interchange for a metro station. Space constraints, both vertically from the low-headroom and laterally from existing pile congestion (friction piles and columns supporting the concert hall) create many complex challenges on this project.



Using in-house capabilities to drive technical innovation

The limited vertical clearance on the site described above meant that Intrafor's Plant Department had to develop specially adapted equipment. An alternative to the mechanical grabs used with excavation cranes was needed as these were too high to fit under the existing station podium and concert hall. Intrafor's design and plant departments developed and assembled special mechanical grabs specifically adapted to operate in a low-headroom environment. This is just one example of Intrafor's capacity to use its in-house capabilities to develop special equipment tailored to different types of projects and constraints.

Innovative deployment of low-headroom machines

The need to overcome constraints including limited vertical clearance, tight space and panel construction at a depth of 60m requires specially designed equipment. Intrafor is one of the very first companies to use the latest generation low-headroom CBC25 cutter - initially built as a compact cutter - to construct a diaphragm wall with a vertical clearance of only 5.5m. The cutter is designed for excavation with a minimum headroom clearance of 5.3m and to depths of up to 80m. The machine's cutter can reach awkward panel positions and is able to rotate around obstacles, which its bigger counterparts can't do. Its steering flap system helps guide the cutter on its way down to ensure control of verticality. The powerful machine can easily cut through rock including granite.

Limited vertical clearance has driven technical innovation by Intrafor's Plant Department.

Innovative gantry use for reinforcement cage installation

To accelerate rebar cage installation in low headroom, Intrafor has developed a custom-made gantry that replaces traditional service cranes. The gantry optimises the cage-lifting operation and allows the cage height to be increased by up to 25% or about 1.5m, reducing the number of cages that need to be spliced per panel. This shortens the production time and saves costs, as less splicing is needed.

The custom-made gantry was developed to install bigger cages

Being hydraulic and electric, the gantry and forklift combination is also an environmentally friendly approach to cage installation as no pollution or noise is generated during the process.

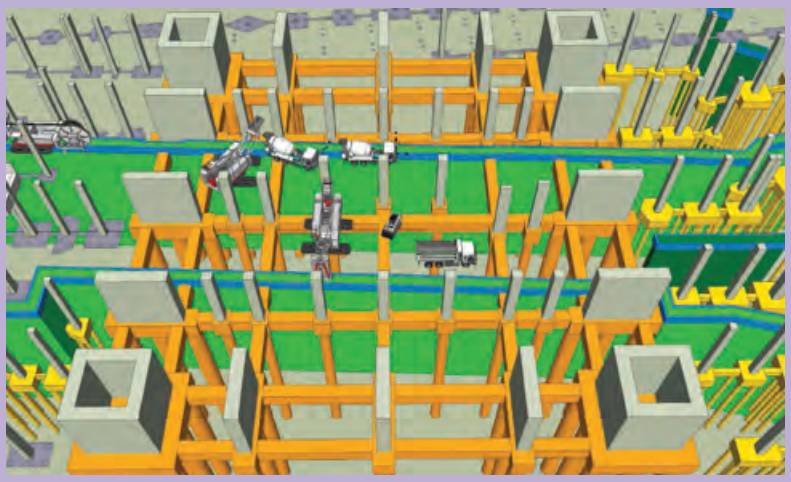
Crucial logistics

Site logistics are a prime concern when working in a congested environment. Manoeuvring equipment requires close supervision and detailed planning to avoid blocking the equipment into corners of the site or damaging existing columns or utilities. Knowing how to move and position the excavation rigs to reach their destinations has become essential, as the experience in dealing with height and width constraints. It usually takes one day to install reinforcement (rebar) cages. However, in a low-headroom environment, cages need to be smaller, which increases installation time to up to three days and has a direct impact on production cycles.

The future of diaphragm walls

Thicker, deeper, faster: the demands on diaphragm wall construction are constantly evolving. Diaphragm walls are being built in increasingly difficult conditions and in geologically harder environments. To cope with reduced headrooms, greater depths, restrictions on noise and dust as well as demands to excavate deeper into hard rock, new generation machines have to be used and construction techniques have to be adapted. Intrafor is actively participating and even driving the industry's evolution and has just patented a new mini-disc cutter wheel (MDCW). Intrafor's innovation, which replaces the usual teeth found on cutters with mini discs, makes it possible to excavate diaphragm walls in rocks such as granite deeper than ever before. ■

Designing for specific site environments

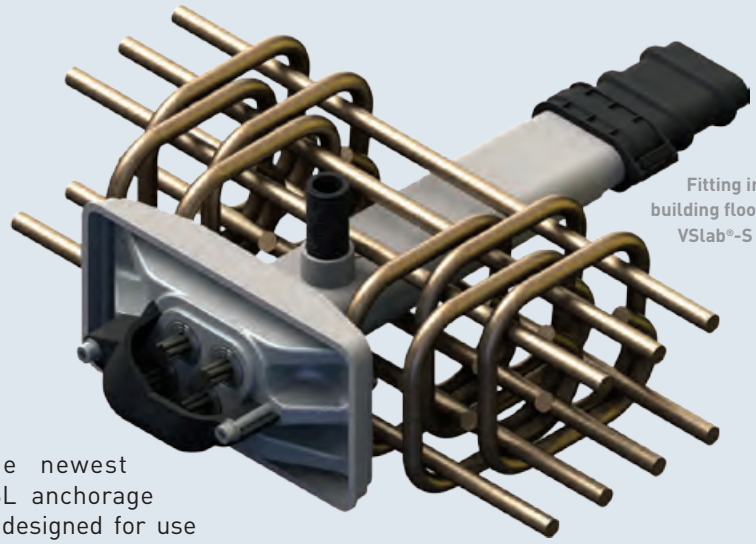


Intrafor is dealing with the unusual challenge of excavating in low headroom in between over 100 existing friction piles and building diaphragm wall panels around numerous beams. The team has used its know-how to optimise the construction methods and plan the site logistics. Intrafor adapted its design to the site, deploying existing machines for new uses and taking into account the different structural obstacles around each wall panel. The design has to cater for the existing structural beams and piles, as well as the utilities and services. In some locations, the site constraints called for rigs to be positioned on top of guide walls to fit between columns.

ANCHORAGES FOR BUILDING FLOORS AND BRIDGE DECKS

VSLab® S – multipurpose

VSLab® S is VSL's new standard anchorage for bonded post-tensioning of building floors and transverse post-tensioning in bridge decks. It has been developed to allow use of 0.6" (15.2 and 15.7mm) strands even in the thinnest slabs.



Fitting into flat building floors: the VSlab®-S Series

The newest VSL anchorage is designed for use around the world as it provides a competitive state-of-the-art bonded slab post-tensioning system. The anchorage has been optimised in terms of reliability and ease of site handling, fulfilling all requirements for a durable post-tensioning system.

Flexibility

The VSLab® S standard anchorage complies with all of the most commonly used national and international specifications, such as ETAG 013 and *fib* PL1+2. VSLab® S can be used as a live-end stressing anchorage or dead-end anchorage respectively. The availability of 2, 3, 4 and 5-strand units provides a high degree of flexibility in the selection of the required tendon capacity and enables the optimisation of post-tensioning details.

The S-Series has been detailed to maximise anchorage efficiency and minimise friction losses. The 2 to 5 0.6" strands of a tendon are placed in flat ducts, which fit into very thin slabs. Even with the optimised anchorage size, early stressing for accelerated construction cycles is still possible.

Enhanced durability

The VSLab® S system consists of a cast-iron anchor body plus a polymer 'trumpet' with a connection to a flat duct. The strands are locked in place with the standard VSL wedge system. Grout caps are available as an optional accessory, further enhancing the durability of the system by providing maximum protection against aggressive environmental agents.

At the same time, VSL's proprietary PT-Plus® polymer duct system range has been extended and is now available for 2, 3, 4 and 5 strands. This allows the new VSlab® S-Series to be used in combination with flat steel ducts or with PT-Plus® polymer ducts, which provide enhanced corrosion protection and reduced friction during stressing.

Short installation time

The 'slap-on' principle - installation of the anchorage after casting of the concrete - offers major advantages to contractors by separating the critical paths of concreting and post-tensioning installation. The resulting short installation times for site work on the critical path are a major advantage of the system.

The VSlab® S system with 2 to 5 0.6" strands per tendon is a highly efficient alternative to the existing 0.5" (12.7mm) systems still in use in some areas. The VSlab® S-Series has been tested for static loads, fatigue loading to two million cycles and to optimise the load transfer to the structure. The system is the latest member of VSL's anchorage family to comply with European Technical Approval Guideline ETAG 013 and offers an appealing new alternative in the building floor construction market. ■

STADIUM ROOF NET LIFTING

Lifting operations - *all in one rythm™*

Millions of fans will be watching the action on the pitch during the World Cup – but engineers might like to take a look upwards to the cable-net roofs installed by VSL.

More than 60 years ago, the Estadio Jornalista Mario Filho - better known as the Maracanã - provided the venue for the truly memorable decider between the host nation and Uruguay in the 1950 FIFA World Cup Brazil™. It was one of the most dramatic chapters in the history of the competition.

The newly refurbished Rio de Janeiro stadium will return to the limelight once again, hosting seven games of the 2014 FIFA World Cup Brazil™. Among those matches will be the final on 13 July. A new purpose-built venue in Salvador will also be playing a key role in the tournament and will host four group matches - three of them featuring top-seeded teams - as well as a round-of-16 match and a quarter-final tie.

Both stadiums feature cable-net roofs installed by VSL using heavy lifting techniques. Cable-net structures are very efficient to cover large stadiums. They are lightweight and can span large areas. One or two circular compression rings above the upper edge of the grandstands act typically as the abutments for a cable net roof. Depending on the type and geometry of the structure, different lifting and tensioning methods can be used.

The membrane roof of the Maracanã Stadium is supported by a single compression ring and three tension rings.

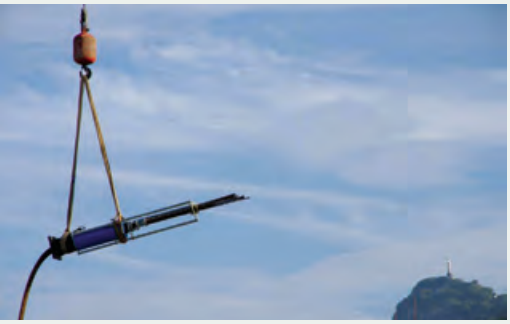
In 2013, one of the world's largest membrane roofs - with a surface area of 203,462m² - was installed during the renovation of the Estadio Maracanã. Its original seating capacity of 200,000 was gradually reduced to now 78,000 to meet current standards. It remains, nevertheless, the country's biggest football ground. The historic façade is untouched but the stadium has been fitted with a new roof, which was installed by VSL. Even during its renovation, the Maracanã continued to attract football fans from all over the world. Visitors could watch work unfold from the specially built Torre de Vidro (Glass Tower), and could even take away a piece of the old stadium as a souvenir.

The roof's enormous size meant that it required a special design. The membrane structure is supported by a single compression ring and three tensioning rings: an upper, a lower and an inner one. In total, 120 SLU strand jack units were installed for the lifting and tensioning. The first 30m lift was for the upper part, comprising the upper and inner radial cables and the upper and inner tensioning rings. For

A variety of equipment was used at the lifting axes including SLU-220/550 units.

the second lift, the strands were loosened again, pulled back down and connected to the lower radial cables. Meanwhile, the client installed the hanger cables and flying masts that connect the upper and lower parts of the cable-net structure. VSL then raised the lower part of the roof structure and the lower radial cables were installed. Tensioning the cables raised the entire structure and the cables were then pinned into place.

A series of lifting operations was required at the Fonte Nova Stadium.



Bringing in the equipment.

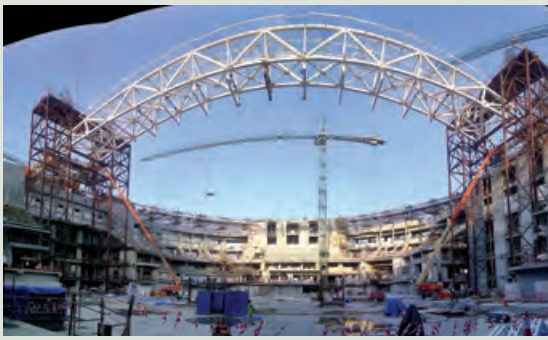
Brazil's original capital, Salvador, will welcome the World Cup with a new 52,048-capacity arena, built on the site of the old Fonte Nova stadium. Officially known as the Estadio Octavio Mangabeira, the Fonte Nova was opened in 1951 and was used until November 2007, then demolished three years later. The stadium that has risen in its place, the Arena Fonte Nova, has been modelled on its predecessor and is covered by a lightweight, cable-net roof. Fonte Nova's roof design is the first of its kind in Brazil. And, another 'first' for Brazil was the method of lifting. Even the Brazilian regulations for working in heights had to be adapted.

VSL was awarded with the lifting contract for the cable-net roof structure, whose design is similar to a previous VSL project, the AWD Arena in Hannover, Germany. Fonte Nova's cable-net roof consists of upper and lower radial cables connected by hanger cables and flying masts. The compression ring is a horizontal lattice structure. At each of the 36 lifting points a SLU strand jacking unit was installed using custom-made supports. VSL worked with its client on a carefully controlled series of operations to lift and tension the upper radial cables and install the flying masts and hanger cables before lifting and tensioning the lower cables. ■

Elsewhere...

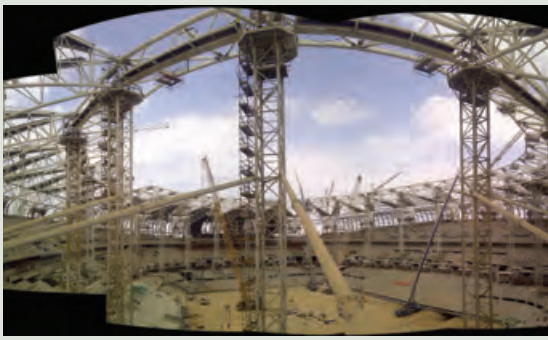
Mega truss lift

The new Al Sadd Sports Club multi-purpose hall in Qatar with a seating capacity of 7,500 has been designed to host basketball, volleyball, handball, badminton and gymnastics events. In January 2014, VSL performed the lift of the roof's mega truss. The 270t truss with a length of 70m and a height of 9m was assembled on ground. It was then lifted by 31m and secured to the permanent columns in one operation within a few hours.



De-propping of the Stadium Roof

The King Abdullah Sports City is a new sports complex located 60km north of Jeddah, Saudi Arabia with a multi-use stadium with a seating capacity of 60,000. During the assembly the roof had to be supported by 24 temporary towers. VSL was responsible for the de-propping operation. After the roof had been lifted, the temporary supports were released, so that the roof could be lowered into its final position. The complete operation was monitored geometrically to avoid differential movement between the 24 lifting points which might cause deformation of the roof structure.



HONG KONG – ZHUHAI – MACAU PRECAST IMMERSED TUBE TU

Innovative uses jacking technolo

China Communications Construction Corporation (CCCC) awarded VSL a contract to design a particularly innovative system for launching the tunnel tubes of the Hong Kong – Zhuhai – Macau immersed tunnel.

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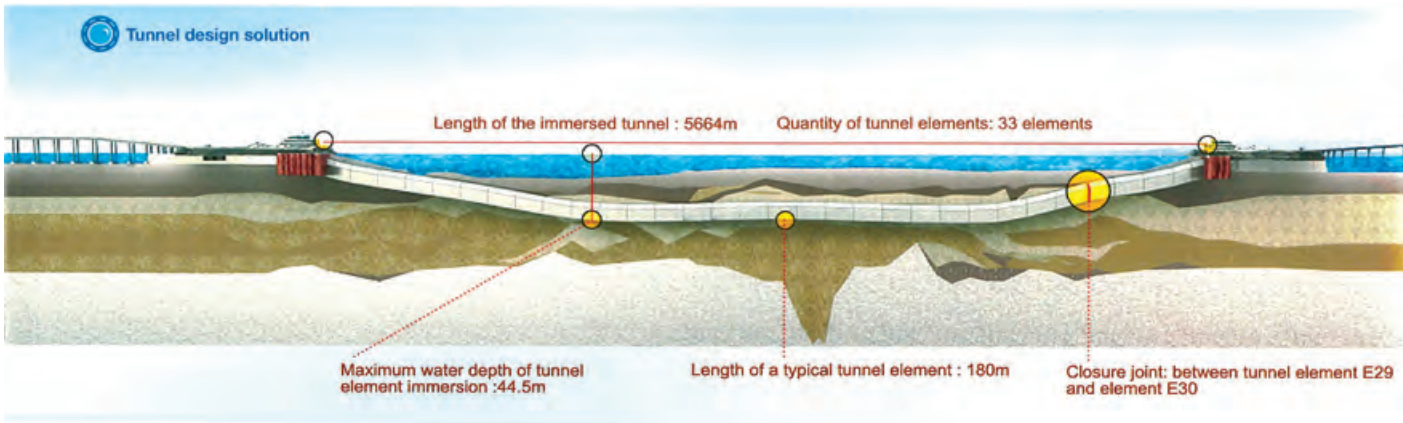
HONG KONG – ZHUHAI – MACAU PRECAST IMMERSED TUBE TUNNEL



Client's comments

Mr. LIN Ming, Project Director
Deputy General Manager
& Chief Engineer
China Communications
Construction Corporation Ltd.

"The project is perhaps the most difficult and challenging ever built, says Mr Lin; *no one has ever built an immersed tunnel of this size before. It requires challenging techniques and innovative engineering, using the best practice in the field for every detail",* he stresses. *"VSL brings new technologies and a positive influence to the local industry,"* he says. *"VSL's innovative ideas are the 'super cars' in the world of civils construction. They are very creative - I am happy to work with VSL."*

"My day-to-day business is to manage the overall project," he says. *This involves managing 5,000 people, dealing with technical challenges and tackling all kinds of issues. One of the great challenges of the project is that nothing similar has ever been done before. Problematic areas had to be identified, which is a difficult task as the project is a first and so there are no previous schemes to refer back to." "I like to be challenged,"* says Mr Lin. *"But I am cautious managing the risk, which is why we took expatriate companies on board. They bring in their knowledge to better assess the risk.*
We undertook an international search for the best practices and chose VSL for its expertise in all the specialist hydraulic issues needed for this project. When selecting a foreign Company, it has to be the best field", says Mr Lin. *"When solving problems, they need to show adaptability. We need to create a relationship in which we feel - and treat each other - as partners."*

1 Turning design into reality

The tunnel is divided into 33 tubes of 180m length, each made up of eight segments that are 22.5m long with a combined weight of 72,000t. The tunnel's cross-section is 38m wide and 11.4m deep, made up of two large cells for a dual three-lane expressway, separated by a central service gallery. The tube segments are produced on an island by the match-casting method. After casting, each completed tube is pushed into a dry dock basin, where it is flooded and then towed out to sea and lowered into its final position.

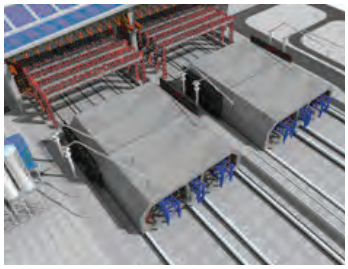
Legend:
- Hong Kong Link Road
- Tunnel section
- Hong Kong - Zhuhai-Macau Bridge

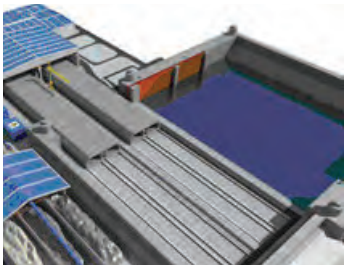
A key section of the Hong Kong-Zhuhai-Macau Link Road consists of a 5.94km concrete tunnel, which will become the longest and deepest immersed tunnel ever built.

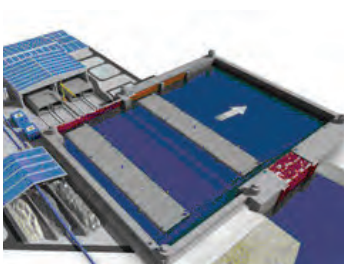
2 Short-line casting and incremental launching

The segments are cast at ground level on two separate production lines, each producing a segment every week. The entire process is built around the short-line casting and incremental launching method, where the eight individual 22.5m-long segments of a 180m-long tube are cast on a fixed bed inside an enclosed facility. Once completed, the entire tube is pushed as one unit into the dry dock, where it is longitudinally post-tensioned, fitted out and made ready for flooding.

The pushing sequence

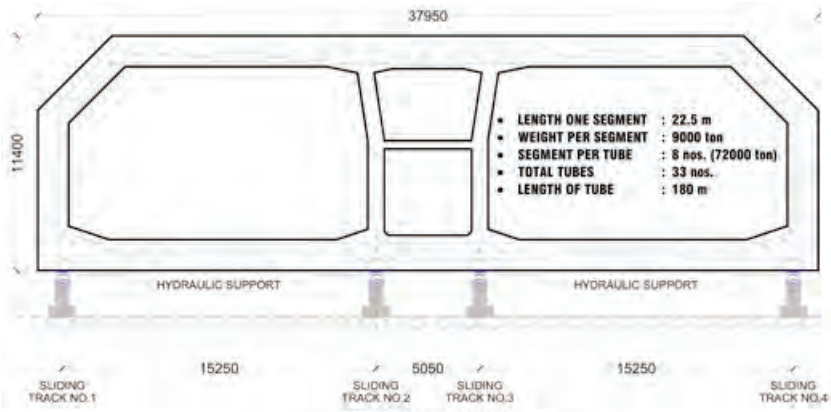






3 Providing vertical support

The segment support system has to ensure even load distribution – in particular during launching over the sliding tracks – to avoid damaging a segment joint or overloading a support point.



TYPICAL CROSS SECTION

HONG KONG – ZHUHAI – MACAU PRECAST IMMERSED TUBE TUNNEL

5 Lateral guide system

Guides at the leading and trailing ends control the lateral alignment of the launched tube. The alignment is corrected by adjusting the jack pressure while the tube is moving.

4 Controlled launching at all times

Previously built units are moved by a multiple jacking system using very large-capacity jacks. The completed 180m-long tube weighing 72,000t is moved over a distance of more than 200m in a computer controlled and synchronised operation that halts the move if any sensor readings are outside the defined range.

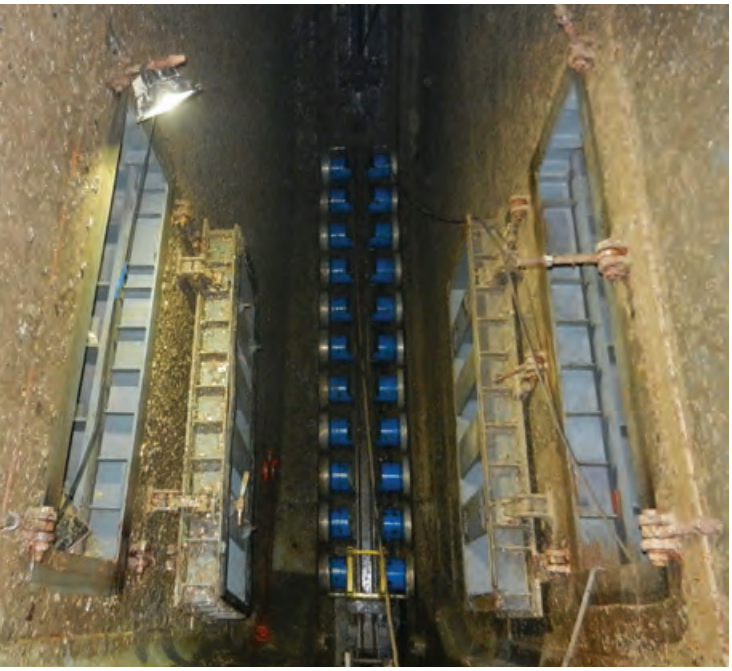
6 Setting a precedent for immersed tube tunnels

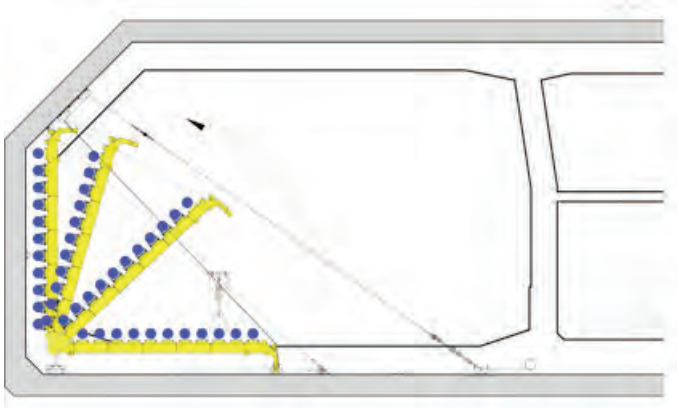
The eight segments that make up a 180m-long tube are longitudinally post-tensioned after casting. Post-tensioning for immersed tubes is typically temporary but for this project it was decided to make it permanent to improve water-tightness across the joints. VSL developed a duct coupler to ensure a fully leak-proof connection.

7 Closing the final gap

Once a new tube has been lowered onto the seabed, it is then joined to the previously submerged section. VSL has designed and supplied the pull-in jacking system for closing the 1,300mm initial gap between sections. One of the main challenges was to design a system that could be used under water and allow quick disconnection by a diver.

HONG KONG – ZHUHAI – MACAU PRECAST IMMERSED TUBE TUNNEL





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Realigning the tubes after immersion
VSL developed a jacking system which allows to make corrections in plan, if the new tube's position is out of tolerance after it has been lowered and joined to the section submerged earlier. A key design feature was to ensure the system could be installed and dismantled mainly manually, without the use of heavy lifting gear, and all within a short period of time.

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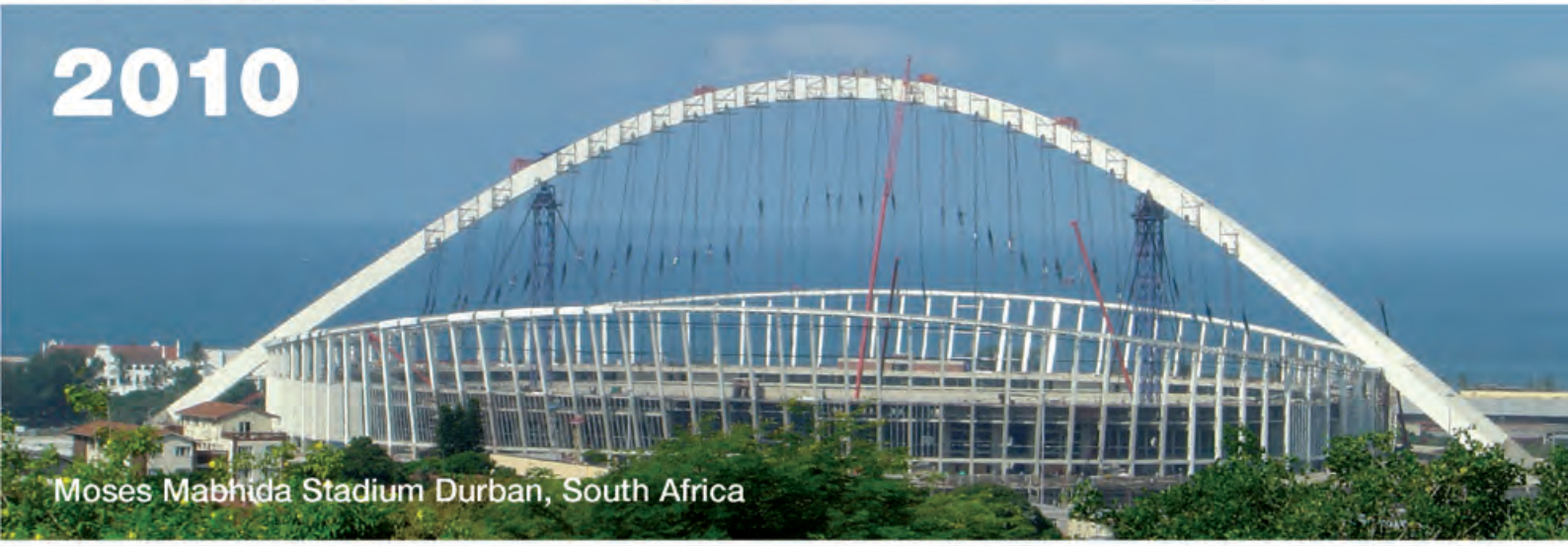

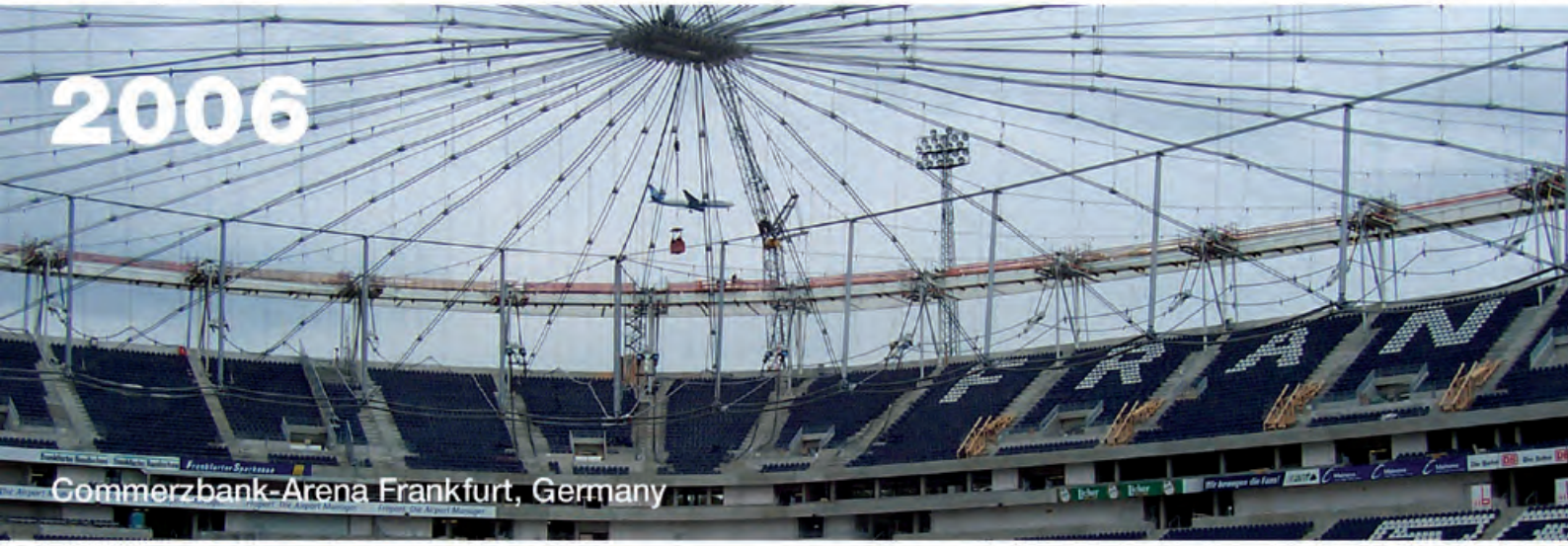

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