VSL NEWS

ISSUE TWO 2000

Kingston Bridge in Glasgow
Scotland

Breaking records at Kingston Bridge

VSL's capacity to handle the most sophisticated projects was once again proven when it successfully completed the world's heaviest lifting operation of a single structure.

The 52,000-t deck of the Kingston Bridge in Glasgow, Scotland, was lifted in October 1999. For 9 months, the bridge was held in position on lifting jacks to keep it open to traffic while the existing piers and bearings were demolished and rebuilt.

The bridge was successfully lowered onto its final new supports in August 2000.

Emphasis should be placed on the extraordinary level of precautions we took to ensure the owner, Glasgow City Council, that under no circumstances would the very weak bridge superstructure be submitted to excessive stresses during the operation. According to the client agent's Engineering Manager, "lifting the deck and holding it there for 9 months with continuous traffic flow over the top demanded world-leading technology."

This exceptional experience will be made available to all customers and assist us in resolving their most challenging technical problems.

Alain Le Pivert
CEO and Chairman of the Board

HIGHLIGHTS

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- SWITZERLAND -

Unique Solution for the Dättwil Bridge

Based on a compelling technical solution, VSL was awarded the post-tensioning works for this prestigious bridge, which will ease traffic congestion around the Baregg Tunnel on the very busy A1 motorway linking Zurich to Bern and Basle.
The construction time for the bridge is critical for the adjacent tunnel which will be built once the 214-m long and 15.90-m wide structure is completed.
The composite superstructure used pre-cast, post-tensioned concrete slab segments with transversal 4 x 0.6" strand tendons which were positioned, individually glued and then stressed together.
Longitudinal tendons using 7 x 0.6" strand were then pulled through and stressed to final load.
The specifications required that the tendons be electrically isolated and replaceable and VSL met these requirements by using monostrands that had been individually embedded in a corrosion-protection compound and a PE encapsulation.

PT works were carried between September and October 2000. ■

Mario Bevilacqua
VSL Switzerland

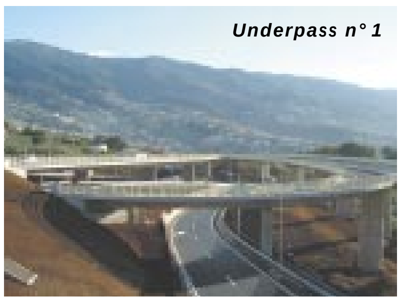
- MADEIRA ISLAND - PORTUGAL -

Funchal Ring Road, second phase

After completing the first phase of the motorway linking the airport to Funchal city in 1997, 1998 saw the Madeira Regional Government launch the second phase of this important road link as well as the construction of the Funchal ring road, an infrastructure deviating traffic around the city centre.
The overall project comprises 13 bridges, 4 viaducts and 9 over/underpasses.
VSL Sistemas Portugal, which has been involved in the development of infrastructures on the island of Madeira since the late eighties, was awarded the major part of the PT (855 t) and stay cabling (50 t of SSI 200) works for this second phase.
The main contractors, Engil, Somague and Soares da Costa, were provided with a complete package, including the supply of 245 pot and reinforced bearings and the supply (820 ml) and installation (430 ml) of expansion joints.

Combóio Viaduct

Underpass n° 1



Works began in December 1998 and continued over several phases through to September 2000.

VSL has also been involved in a number of civil works on the roads running from the north to the south of the island of Madeira and is currently working on a viaduct extension running under the new airport runway. ■

Eric Feigenbaum
VSL Sistemas Portugal

- MAINLAND CHINA -

Ching Chau Min Jiang Cable-Stayed Bridge

At midday on the 19th of August 2000, following a 6-month period during which VSL had constantly been on the site's critical construction path, the main span of the Ching Chau Min Jiang Stay Cable Bridge was successfully completed. This bridge is part of a toll road linking Mawei District to Changle International Airport in Fuzhou Fujian Province.

The bridge's two pylons were designed as double diamond-shaped pylons with variable stay deployments.
With a 605-m main span and two 250-m approach spans, the bridge is ranked as the fifth longest cable-stayed span structure in the world and the longest composite deck cable-stayed bridge in the People's Republic of China.

Apart from the supply contract for the stay cable components, awarded to VSL Hong Kong in December 1998 by Hong Kong Construction (Holdings) Ltd. through their materials supplier, Mitsui (Hong Kong) Ltd., a second contract for the provision of site supervision, stay cable engineering and equipment rental was directly awarded to VSL by Hong Kong Construction (Holdings) Ltd. in August 1999.

A third contract was awarded to VSL China in late October 1999 by Hong Kong Construction (Holdings) Ltd for the provision of labour and temporary equipment.

Stay cable installation works began in mid-February 2000. VSL SSI 200 stay cable anchorages (6-27 to 6-85) were used on this project and stay cable lengths ranged from 80 m up to 315 m.
Galvanised, wax and polyethylene coated strands were installed using VSL's newly developed double strand threading method. All strands were individually stressed using VSL's Automatic Stressing system, a technique that takes advantage of recently developed ISO-Elongation stressing technology.

On request from the bridge designer, VSL introduced an extra de-tensioning capability by installing 120-mm pin guided adjustment shims in all stressing anchorages.
Strand bundles were protected by co-extruded high-density polyethylene stay pipes with a milky-white coloured external face.

Main participants

The bridge's main contractor and coordinator, was Hong Kong Construction (Holdings) Ltd., formerly called Kumagai Gumi (Hong Kong) Ltd. The 29-m wide steel girder and concrete panel composite bridge deck structure was erected using the balanced cantilever method by the Shanghai Construction Group which also assembled the two 197-m high concrete pylons.
The bridge foundations were constructed by the Ministry of Railways engineering division construction department.

The project was launched by the Fuzhou Municipal Government and the bridge client is the Fuzhou Guangmin Road & Bridge Company, a joint venture set up by the local government and Hong Kong Construction (Holdings) Ltd.

Buckland & Taylor, a Canadian consulting firm, was employed by Hong Kong Construction to act as design consultant. The resident Bridge Engineering consultant was the Shanghai Tongji University Residency Engineering Company.

Stay pipe surfaces were provided with double ribbed high-density polyethylene strips to reduce the rain-wind vibration effect.
The stressing anchorages were all positioned within the pylons while the non-stressing anchorages were positioned on top of the deck in suspended steel structure bearing plates.
In accordance with the contract agreement, a total of 2,300 t of 0.6" strands were supplied by the main contractor to VSL for the installation works.

By concreting every second in-situ joint in the bridge deck at the same time to reduce the curing time of the concrete joints in between the segments and concrete panels, the bridge deck construction cycle attained an average of 4.5 days per segment.
In order to meet the tight construction schedule, stay cable works were carried out in 12-hour shifts, two shifts per day, seven days a week.
VSL's site team, representing over six nationalities, had to maintain a constant workforce on site through-out the entire construction period, in order to be able to simultaneously install, stress and adjust stay cables on both pylons.

The works on the Ching Chau Min Jiang CSB allowed VSL North East Asia's stay cable division to train a number of local Chinese engineers, site supervisors and site employees, meaning that VSL now has additional expertise for the future construction of other stay cable bridges in the country.

Pelle Gustavsson
VSL North East Asia

- NETHERLANDS -

TWISTVLIETBRIDGE ZWOLLE

Three rivers — the Ijssel, the Vecht and the Zwartewater — surround the city of Zwolle, capital of the Dutch province of Overijssel. In 1996, the construction of a new district was begun on the far banks of the Zwartewater. This new urban area, known as Stadshagen, is directly linked to the old city thanks to the construction of two bridges.
In May 2000, the second bridge, the Twistvlietbrug, was opened to pedestrian, cyclist and city bus traffic.

Owned by the Municipality of Zwolle, this 171-m bridge is split into 3 main sections: a 112-m cable-stayed bridge with two central pylons, a bascule bridge with a 28-m steel deck, and a 31-m viaduct with a post-tensioned concrete deck.
The width of the bridge is 13 m but widens to 25 m and 30 m in two places to provide viewpoints 6 m above water level from where people can watch passers-by, both on the river and on the bridge.
The main contractor, Hegeman and Nijverdal, awarded VSL the post-tensioning (17 t) and stay cable (28 t) works. The 24 stay cables consist of 16 to 31 strands (0.6" - 1,860 Mpa) covered by a tightly extruded polyethylene coating filled with petroleum wax. Each bundle of strands is fitted into a polyethylene tube which, near deck level, is provided with a stainless steel protection.

The VSL 200 anchorage system was modified to provide increased corrosion protection for the bottom anchorages which end in a recess underneath the concrete bridge deck. The top anchorages are housed in two pylon heads. These heads have been designed as 8-m high oval-shaped hollow steel boxes with a 4-m open eye on the top. All top anchorages are threaded to allow potential adjustment of the force in each individual stay. The initial stressing of the stays was carried out strand-by-strand using a mono-jack.

Stay installation
Stays were fitted by assembling the bottom anchorage on the deck.
The top anchorages were assembled in the pylon head manufacturer's workshop. The polyethylene stay pipes were butt-welded on the deck, hoisted up to the vicinity of the top anchorage and fixed into position using an electro-coupler.
The strands, already cut to fixed lengths, were then winched up individually, fixed to the top anchorage and stressed. This part of the operation was facilitated by the telescopic properties of the anti-vandalism tube.
Depending upon the engineer's instructions, stays were stressed in either one or two phases to a preliminary fixed elongation. After each stressing operation, the relevant data were fed back to the engineer for comment and eventually correction of the stay force. On no occasion was a correction necessary.
It is interesting to note that all strands and stay pipes were positioned without a crane.

Wim Vellekoop
VSL Benelux

- KOREA -

Giant roof structure lift

The new Inchon City international airport in Korea comprises an underground traffic terminal with a central area covered by a 16,000-m² shell-shaped space frame structure. Due to time constraints, the main contractor, Samsung Corporation, decided at an early planning stage to assemble the two roof sections some distance away from the actual site of the terminal and then to launch them once concrete works were completed. VSL Switzerland, along with VSL Korea which provided local support, supplied the design assistance necessary for the sliding devices as well as the equipment and specialised staff required to carry out the launching operations in several stages and, over a maximum distance of 180 m. The heavier of the two roof sections weighed 4,200 t, and propulsion force was provided by two strand-pulling units, each arranged in tandem mode. This system allowed the roof to be continuously moved at a speed of up to 20 m per hour. The equipment was installed last April, and launching operations took place between May and August 2000. ■

One of the roof sections during launching. The red structures are temporary constructions used for the erection and sliding-in operations.

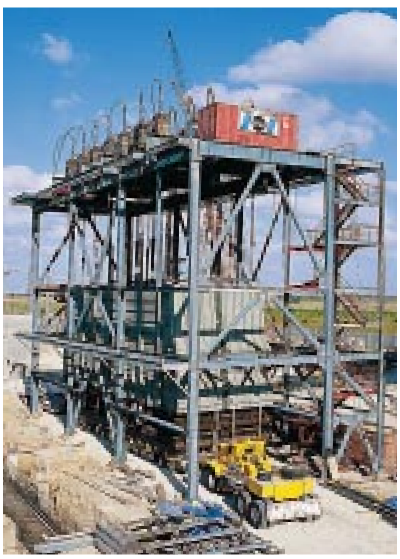
Two synchronised tandem arrangements provided the required pulling force.

Ferdi Trenkler
VSL Switzerland

- MEXICO -

Boiler lifts for the Río Bravo Cycle Power Station

The Río Bravo Combined Cycle Power Station in northern Mexico comprises two boiler units which transform the heat produced by the gas turbines into steam for additional energy production.



VSL Mexico decided to seek the cooperation of VSL Switzerland for methods and to cost the lifting of the two boiler assemblies.
Following their award of the works from steel contractor Keppler, VSL Mexico entrusted VSL Switzerland's Heavy Lifting department with the design, supply and operation of the required lifting and control equipment. The lifting installation, which included fourteen SLU-70 units and seven SLU-120 units, had to handle a total load of over 1,000 t. Lifting operations took place between June and August 2000.

Following this first lifting operation, VSL Mexico obtained a subsequent contract for lifting and placing four equipment units, i.e. one gas turbine, two gas generators and one vapour turbine. The VSL designed lifting procedure and equipment for the two turbines and the two generators were very similar. First a working platform was introduced between the two lifting towers, then four steel slings were placed around equipment unit gudgeons, and the equipment units were lifted by the 70-t jacks prior to be pushed through to their final positions.
By using the resources available on site for these lifting operations, VSL came up with fast and economic solutions for the main contractor and signed a new reference for heavy lifting works on the Mexican market. ■

Peter Siegfried (VSL Switzerland)
and Alain Rossetto (VSL Mexico)

- INDIA -

A VSL India breakthrough for PT in building

The Sai Radhe Multiplex, a shopping and office complex, is the first building project undertaken in India using the VSL post-tensioned slab system.
The 9-storey building with 2 basement levels is located in Pune, one of the biggest cities in India about 200 km south of Mumbai. Works began in April 2000 and are scheduled for completion by December 2000. When completed, the building will have a surface area of around 50,000 m².

VSL was awarded the project with an alternative design based on a system using post-tensioned flat slabs with drop panels. This structural system proved to be more economical when compared with the conventional reinforced concrete grid beam and slab solution.
VSL's scope of works includes the design of 24,000 m² of PT slab with drop panels from the fourth storey up to roof level.

The PT works involve supply, installation, stressing and grouting of the slab tendons.
In addition, VSL helped the main contractor, Sai Construction PVT Ltd, to plan the floor construction sequence. ■

R.M Ganesh
VSL India

- USA -

PT solution for the Icehouse office/retail building

The Icehouse Building once completed

The Icehouse is a multi-use office/retail building located in an architecturally-sensitive historic section of downtown Denver. The project team was led by the Neenan Company, the largest design-build contractor in Colorado.
As part of the design-build team, VSL provided engineering of the parking level slabs, furnished the post-tensioning system, and installed the post-tensioning and mild reinforcement.

Phasing of the structure was unusual in that the three levels of below-grade parking were constructed as the steel superstructure was erected.
Height limitations, shallow groundwater, and long spans resulted in the decision to use a post-tensioned wide/shallow beam system because of its minimal depth and overall economy.

Special detailing was required for stressing the tendons since the edges of the slabs were not accessible.
VSL's early involvement in the planning of the project contributed to its success. ■

Dan Harger
VStructural Llc.- Denver

- HONG KONG -

MTRC Tseung Kwan O Extension Contract 612 EHC Tunnels

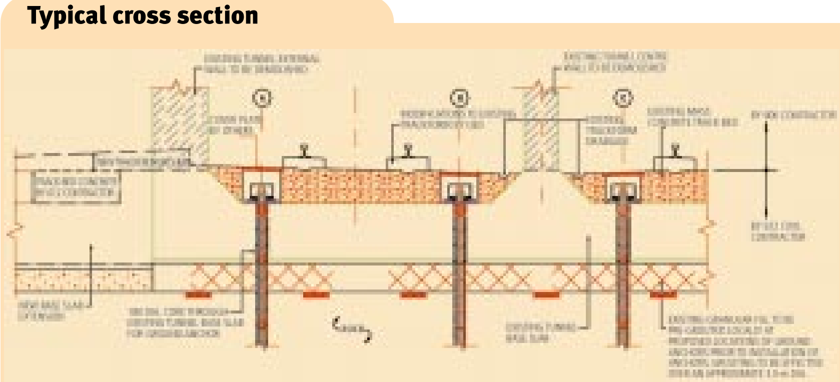
As part of the preparation works for the connection of the Mass Transit Railway Kwung Tong line to the new Tsuen Kwan O Line, a series of sixty-five VSL E6-6 permanent ground anchors needed to be set into the existing tunnel base slab prior to the demolition of the central and side walls. These anchors have a design working load of 800 KN and vary in length from 17 m to 20 m.

VSL's scope of works included the design, supply and installation of the permanent anchors, as well as pre-grouting in the granular fill layer beneath the existing track slab and above the rock head. Works were carried out at night during traffic-free hours from 01.45 a.m. to 05.00 a.m.

The anchors have a design life of 120 years. A double corrosion protection system using the VSL PT-Plus Duct system was utilised as internal and external sheathes. After insertion, each anchor was subject to pinhole testing using an electric resistance measurement method, to make sure there was no damage to the anchor sheathing. A 3-mm thick Cevolit plate was installed at the bottom of the anchor heads to provide stray current insulation.
The existing tunnel track slab is located at -10 mpd, being about 12 m below sea level. The construction sequences were as follows:

- installing deep wells to draw the water level below the track slab level;
- coring a 550-mm ø hole through the mass concrete slab for installation of bearing plates and jack recesses;
- coring a 180-mm ø hole through the reinforced track slab for pre-grouting to the granular fill beneath the slab;
- drilling a 150-mm ø hole through the 180-mm ø cored hole for anchor installation, and water testing to bond length;
- inserting pre-fabricated anchors and grouting;
- stressing and monitoring anchors;
- long-term monitoring by lift-off tests and electric resistance measurements.

Typical cross section



All construction equipment (generators, air-compressors, drill-rigs, grouting equipment, ventilation fans, lighting etc.), and materials were stored in wagons provided by MTRC and towed to the job site by diesel engine locomotives. Two identical sets of equipment were deployed, one for up-track and one for down-track.
Pre-grouting, drilling and anchor installations began in December 1999 and the anchoring was completed by mid-April 2000. Monitoring operations will continue up to the end of the maintenance period in 2004.

To ensure that the Mass Transit operation was not interrupted, the construction method and work sequences were planned well in advance: daily site meetings were held prior to the beginning of each shift and review meetings held at the end of the shift. Thanks to the good co-ordination and co-operation between the main contractor and the VSL site team, works were well carried out and met the schedule. ■

Lewis Wong
VSL Hong Kong

- SPAIN -

Completion of Lindavista Retained Earth Walls

The development plan for the city of Cornellà de Llobregat (Barcelona - Spain) includes a project for covering 300 metres of railway track in the Lindavista district with a pedestrian promenade and a small park.
This new link will connect the city's quite isolated residential area to the recently built retailing area.

The railway track project was awarded to Ferrovial-Agroman. The cover consists of transversal beams carrying the upper slab of a bridge and retained earth walls to support the abutments. Approximately 5,300 m² of VSL retained earth walls (VSoL) with a maximum height of 16 m were installed along each side of the railway track.

CTT Stronghold was awarded the design and the supply of all VSoL components and also provided technical support. The walls were provided with an aesthetic smooth square 1.5-m x 1.5-m finish to blend into a highly populated residential area. To meet the client's aesthetic requirements, no less than 150 different types of pre-cast concrete panels were needed.

The VSoL system proved to be fully adapted to the site's clayey soil.
As the soil composition (small particles) did not meet standard soil requirements, VSL carried out a number of preliminary tests by first erecting a 6-m high wall to prove the efficiency of the system. Given that the crossbars mobilised the soil thrust, the system successfully passed the tests. The competing frictional systems would have been highly inefficient in this type of clayey soil.

The VSoL system also meant that the site soil could be used, leading to time and cost savings for the contractor.

The completion of this project, the first of its kind in Spain, is an important step forward for CTT in developing the retained earth activity in the country. ■

Sophie Leveaux
CTT Stronghold

No less than 150 different types of pre-cast concrete panels were used on this project.

- HONG KONG -

KCRC 601 VSoL Walls

As a part of the massive West Rail infrastructure project currently under construction in Hong Kong for the Kowloon - Canton Railway Corporation, the 601 contract includes 42 retaining structures using cast in-situ or bored pile construction methods.
As part of an aggressive redesign to save both time and money on the project, the main contractor proposed a VSL alternative design to replace 30 of these structures with VSoL walls.
Ranging in height between 3.5 m to 15 m and with a total surface area of 10,000 m², the VSoL wall system is using 1.4-m by 1.5-m rectangular panels with a plain ribbed finish for the first time in Hong Kong.
The system has a design service life of 120 years and the VSL's scope of works includes both internal and external design for the walls, as well as the supply of the products, i.e. pre-cast panels, reinforcement mesh and joint materials, delivery to the work site and on-site supervision. ■

First use of rectangular VSoL panels in Hong Kong

Stuart Pearson
VSL Hong Kong

- VIETNAM -

Completion of a first VSoL project

Under the technical supervision of Pacific Consultant International of Japan, the VSoL system was selected for retained earth segments of the works for the MET Bridge in Lang Son Province, Northern Vietnam, a project financed by Japanese Overseas Development Aid.
The project's main difficulty was the need to build the 6.5-m high VSoL walls on very poor ground, between two reinforced concrete abutments set on pile foundations.
With assistance from the Hong Kong based VSL Geotechnical Division led by Richard Austin, settlement analyses were carried out and advice concerning ground improvement measures was given to the Consultant. Construction was successfully completed by local VSL Vietnam staff, in collaboration with Cienco 5, the client and local main contractor for the project.
Chosen for its technical and economical performance, the VSoL system has now made its first breakthrough on the Vietnamese market. Considering the number of site visits and expressions of interest received concerning this project, VSL can look forward to further opportunities to promote and use this technology in Vietnam. ■

Laurent Peguret
VSL Vietnam

- USA -

University Hall Strengthening

University Hall, located in Charlottesville, Virginia, is the home of the University of Virginia men's and women's basketball teams. With a seating capacity of over 9,000, it serves as a key sports and entertainment facility for the region. The building, originally completed in 1965, is covered by an 87-m diameter concrete dome. The dome consists of 32 pre-cast segments with a cast-in-place thrust ring that was originally prestressed by being wrapped with smooth wire. During a recent structural inspection, corrosion of the prestressing wire was discovered. Emergency repairs were immediately performed using external monostrand tendons.

Severud Associates, a structural engineering firm in New York City, was retained by the University to design a permanent repair solution. Severud's design consisted of 15.2-mm double extruded external monostrands passing through 32 deviators positioned at locations around the dome's perimeter that coincide with the pre-cast segment joint locations. The tendons were to be stressed with single strand, centre stressing monostrand anchorages located midway between the deviators.

VSL, working together with the main contractor, Structural Preservation Systems, and Severud Associates developed an alternative solution. The alternative consisted of 4 hoops of 6-10 external multistrand tendons. Each hoop consisted of 4 tendons that were anchored and stressed at 90 degree intervals. The tendons were arranged so that no more than one tendon was stressed at each deviator location. Special anchorages, using pre-grouted guide tubes similar to stay cable anchorages, were designed and fabricated to allow strands to pass by opposing strands without pinching. This arrangement made it possible to install and stress the tendons strand-by-strand using lightweight monostrand equipment. The tendons were fully encapsulated in high performance, co-extruded HDPE ducts that were grouted after stressing to ensure long-lasting durability. The project was completed in September 2000. ■

John Crigler
VStructural Llc.- Baltimore

- SCOT

Challenging repair works

LAND -

for the Kingston Bridge

On October 1999, VSL carried out the world's heaviest lift of a single structure: the 52,000-t deck of the Kingston Bridge was raised off its piers by 15 mm and maintained on temporary supports over a 9-month period, thanks to one of the most complex and sophisticated jacking networks ever designed.

Partial view of B and C jack systems

Kingston bridge is one of Europe's busiest motorway crossings. Traffic continued uninterrupted over the suspended bridge during the overall refurbishment works.

The Kingston bridge over the River Clyde in the centre of Glasgow is one of Europe's busiest crossings.
The bridge supports the strategic M8 motorway which links Glasgow and other major industrial towns lying west of Scotland's central belt to Edinburgh on the east coast.
The bridge carries more than 155,000 vehicles per day.

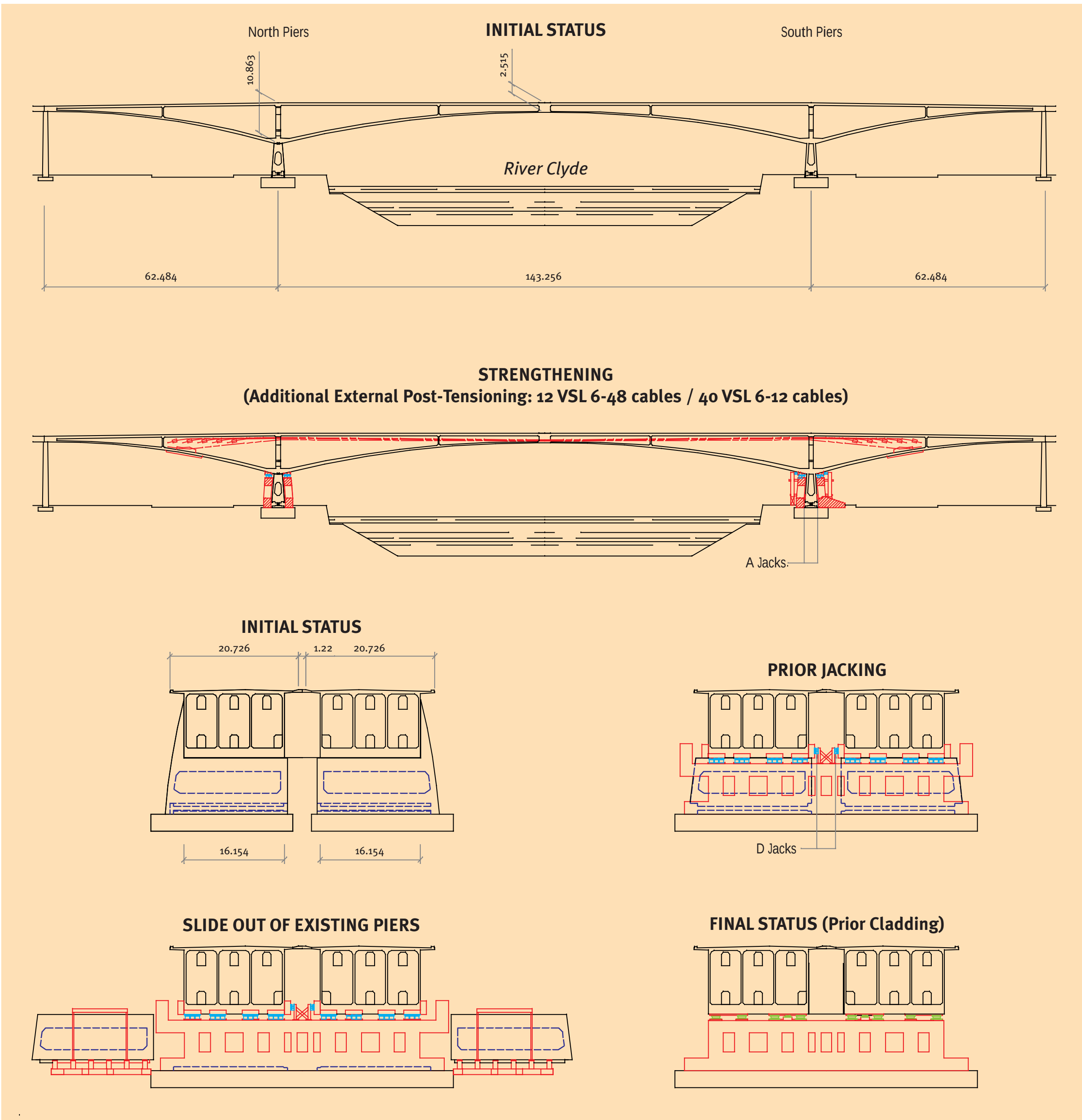
Description of the bridge

The 30-year old concrete bridge was designed as a semi-portal 268.3-m long structure comprising 3 concrete box girder spans (62.5 m + 143.3 m + 62.5 m) and concrete pier supports. The deck was simply supported at the abutments.

The south pier is 8.2 m high and was constructed monolithically with the deck at the top forming a moment connection. It was pinned on the foundation and formed a fixed point. The north pier was pinned at the top and at the bottom and therefore worked as a large 8.2-m high rocker.
Transversely, the bridge cross-section combined two adjacent parallel decks, carrying the dual five-lane carriageways.
The bridge was erected by the free cantilever method using in-situ prestressed segments.

Status of the bridge

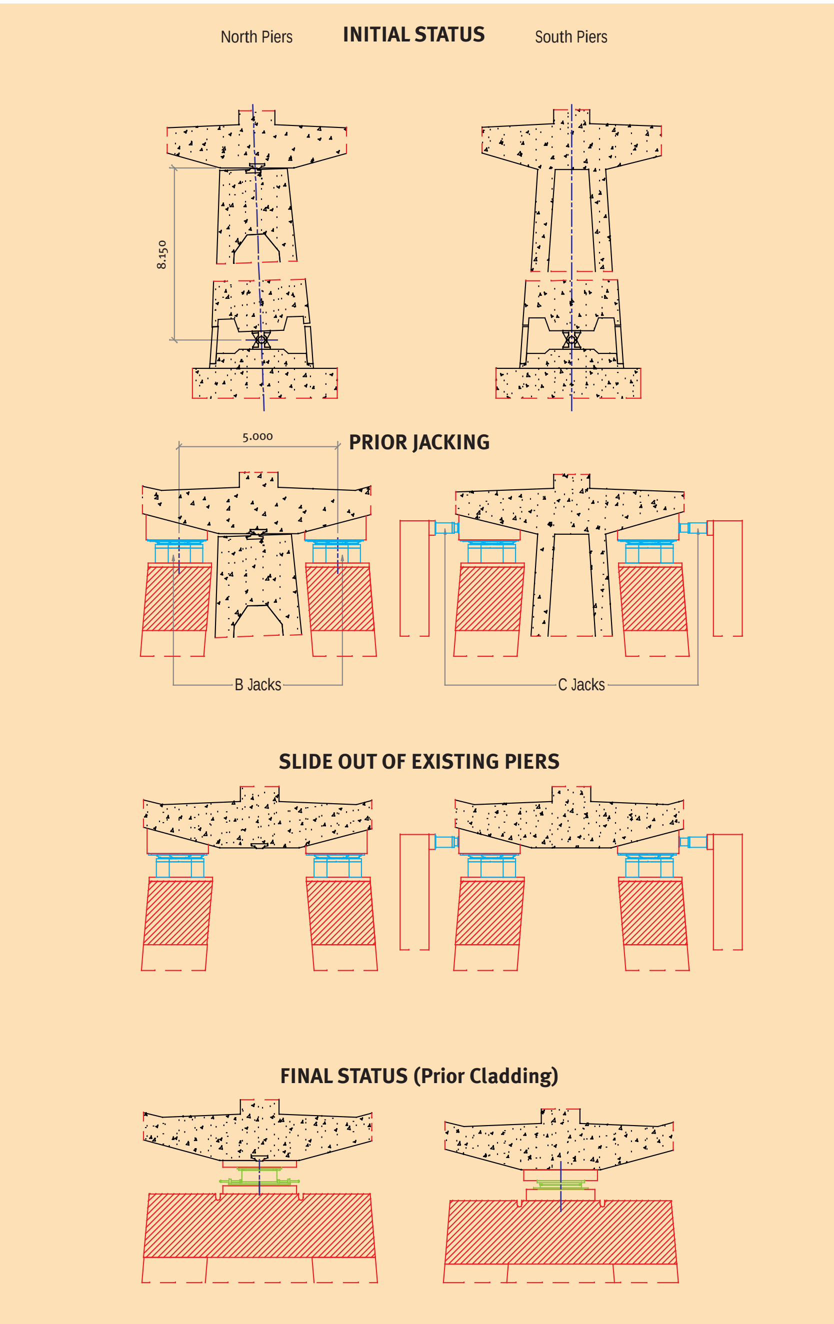
During inspections of the bridge in the late 1980's, it was found that in addition to significant cracks, the bridge deck had deflected downwards by 300 mm at mid-span. Subsequent investigation



concluded this was due to losses of the residual PT force combined with the effect of long-term (creep) deformation. Both effects are well known causes of excessive deformation in this type of structure. In addition, inspection operations revealed a number of other serious defects including a 165-mm out of plumb at the north piers, damage caused by the main bridge exerting forces onto the north approach viaduct, under-strength foundations due to eccentric loadings and quay wall movements at the river edge.

The refurbishment project

At the beginning of 1990's, when VSL began working on preliminary design studies, it was evident that longitudinal strengthening of main span using additional external PT was appropriate. On the other hand, it was not clear how best to improve the articulation arrangements to solve the problems of the main piers' stability and strength. VSL proposed simplifying the structure to a traditional simply supported 3-span girder on modern bearings to avoid any horizontal internal forces.



VSL undertook extensive feasibility designs for the structural concept and developed the principles of an appropriate Jacking Control system able to allow the structural changes to be made without significant closure of the bridge.

In the mid 1990's, Glasgow City Council issued tender documents for the refurbishment works. The tender required the design and construction of a strengthening solution involving additional PT cables and the replacement of bridge's two main pier shafts and the bearing system. Balfour Beatty Construction Ltd. as main contractor for civil works, BWM as subcontractor for PT works, and VSL as sub-contractor for jacking operations were chosen to undertake the complex challenge.

The Strengthening

The main span strengthening works comprised the installation of concrete anchor blocks, including cable anchorages connected to the side span webs and bottom slabs, by post-tensioned bars. Deviator systems were installed through the main pier diaphragms to change the directions taken by the cables.
PT cables were subsequently installed in HDPE pipe in between opposite anchor blocks to form an array of 52 external PT tendons. Tendons were stressed in stages as installation and refurbishment progressed.
The set of new VSL external tendons (200-m long each) developed an additional force of 90 MN per deck.

Change of structural behaviour

In order to change the structural arrangement of the bridge, new external columns were placed to either side of the existing piers (to support the temporary jacking systems) and connected by transverse capping beams. On completion of the new pier construction, new bearings would be installed.
The jacking system specifications laid down the geometric and loading constraints which had to be met by the jacking control system at all times while the bridge was being loaded and supported by the jacking system.

The bridge arrangements precluded the possibility of placing a central pinned bearing at the permanent support position (which was initially occupied by the original piers to be demolished) so the jacking had to be performed by longitudinally linked and hydraulic balanced active supports, located 5,000 m apart, to allow rotation due to live load, temperature effect, etc.
This ensured that the effective bridge span remained unchanged during the works.

Design of the Jacking Control System
The Jacking Control system comprised an integrated system of mechanical, hydraulic and electrical components able to provide the permanent active control of the structure. The Kingston Bridge Jacking Control system was sub-divided into systems A, B, C and D.

- system B gave vertical support thanks to 128 jacks of 1,000-t capacity installed on new columns and reacting against down-stand plinths connected to the decks. The B system comprised 32 "active" jacks per pier to support the bridge and 32 "reserve" jacks to ensure available back up in case of failure of the active ones. Each jack was equipped with a locking collar as an ultimate rigid safety support in case of the double failure of the active and reserve jacks. All B jacks were capped by sliding and rotating devices to permit horizontal and rotational movement.

- Systems A, C and D were horizontal jacking systems including over 100 jacks, each with a 200-t capacity.

The hydraulic and electronic components
- The hydraulics included drive pumps, accumulators, associated general control boxes and valves and, close to the jacks, remote individual hydraulic control boxes comprising direction control valves and associated jack control devices. All these hydraulic components were computer controlled and operated as the input/output of the Control system.

Slide out of main pier shafts

- The electronic components comprised instrumentation devices, programmable logical controller and a supervision system. Because the bridge had to remained open to traffic while it was supported by the jacks, a triple validation of the critical instrumentation components was required. Associated hydraulic systems ensured that the bridge would be fully supported at all times.

The Jacking Control system software comprised programmes for the A, B, C and D systems and was managed by a global programme based on a matrix of permissible combinations of tasks.
The programme for system B was the most sophisticated and comprised numerous routines for checking correct functioning, calculating the bridge position and loading status, checking that all bridge elements were within tolerances on position and loading distributions, and substituting reserve jacks for active ones whenever required, and reversing the operation following repairs.

To manage the processing of more than 1,000 parameters and input or output data items, the programme required over 12,000 coding steps. In addition, the programme was able to identify failure or irregular conditions and could report more than 3,000 different alarm messages.

Stringent test phases
The basic action at the interface in-between the jacking control system and the structure was designed, and then proven during tests and operation, to be a displacement resolution of 0.1 mm and a load resolution about 1% of maximum loading.
Because of the complexity of the system, the design period was extended by more than 3 months to allow for a very sophisticated sequence of factory acceptance tests and to demonstrate that the Jacking

Control system would comply (under all circumstances) with specifications. Two test rigs were built, one for horizontal systems A, C and D and one for vertical system B. The test rig for system B represented half of one main pier and included a reacting test control system to simulate the permanent constant loading of the deck four webs. The intention of the B test system using an adequate model was to provide a reliable simulation of the real bridge situation. These tests were followed by a further series of on-site tests to confirm the satisfactory functioning of the system components under nearly full working conditions.

The lift operations

The 15-mm jacking up of the 52,000-t deck and the 30-mm push southward to free the bridge of its supports and approaches were carried out during two week-end night-time traffic closures in October 1999.
The Jacking Control system was then placed in maintenance mode. In this mode, the bridge position and pressure status of the complete hydraulics system was continuously monitored and if necessary corrected to ensure the bridge remained within tolerances on position and load distributions. This mode allowed all associated civil works including the removal of the original pin bearings, the demolition of the four 800-t existing pier shafts and the capping beam erection to be completed without any traffic disruption.
On completion, eight 41,000-kN capacity pot bearings to the south and eight 41,000-kN capacity elastomeric bearings to the north with their associated guides were installed on flat jacks on the capping beam.


Partial view of test rig for vertical B jack system

In August 2000, during 3 week-end night-time traffic closures, bridge adjustments were carried out by lowering and pushing the bridge southward once again and, after lowering to a precise level, the flat jacks were grouted to present new bearings against the correctly positioned bridge. After curing of the grout, the final load transfer from the Jacking Control system to new bearings was completed.

Conclusion

The Kingston bridge continues to cross the Clyde, and its use as Scotland's most important bridge crossing has been assured for a long time to come by the successful completion of this difficult refurbishment project which depended so much on state of the art solutions for active control engineering in the field of jacking; a solution designed, installed and operated by VSL. ■

Lucien Boutonnet
VSL TCEU

Main participants:

- Owner: Glasgow City Council
- Consultant: Gifford and Partners
- Civil Works Contractor: Balfour Beatty Construction Ltd
- PT Works: BWM
- Jacking Works (design, supply, installation and operation): VSL

As a bridge specialist, VSL provides different services such as detailing and alternative designs, optimisation of construction procedures and methods, design and detailing, operation and supervision of formwork systems, form travellers for cast-in situ decks and geometrical control of bridge decks for pre-cast and in-situ construction. In addition, VSL also provides special lifting and launching equipment, such as erection trusses and gantries, that can be custom-designed to suit almost any bridge project. Our scope of services also includes superstructure erection and site supervision.

Pakse Bridge in Laos

- PHILIPPINES -

Cebu South Coastal Road Project

Cebu Coastal Road pre-casting yard

The Cebu South Coastal Road Project, Segment no. 3, is a 1.4-km bridge project over water just offshore from the City of Cebu in the Southern Philippines. Owned by the Government of the Philippines with financing from a Japanese government loan, this infrastructure project represents an important second road link from the southern areas of Cebu Island to Cebu city.

The main contractor, Taisei-Marubeni JV, awarded VSL a large scope of works including the pre-casting and erection of 320 type 4 AASHTO I-beams (34 to 36.75-m long) over a 16-month period. In addition VSL will supply and install 1,760 elastomeric bearings. The overall project represents 7,850 m^3 of concrete, 1,080 t of reinforcement and 380 t of PT.

The casting yard was set up by VSL on land provided by the main contractor with water access 4 km from the bridge site. The I-beams will be delivered to the site by barge and erected by VSL using an overhead self-launching girder. The VSL Project team began pre-casting the I-beams in September 2000 and will have completed the operation by January 2001. As of mid October 2000, VSL had pre-cast thirty-three I-beams and was already ahead of schedule. Bearing installation and I-beam erection are scheduled to begin early in 2001 and will be completed within a 12-month period.

Geoff McKinnerey
VSL Philippines

- CHILE -

THE AMOLANAS BRIDGE

As part the concession system in Chile, Sacyr Chile S.A. was awarded the construction of the Amolanas Bridge, the highest highway viaduct in the country. Owned by Concesiones del Elqui S.A. and located 310 km north of the capital Santiago, the bridge is one of the most imposing structures in the country.

Characteristics

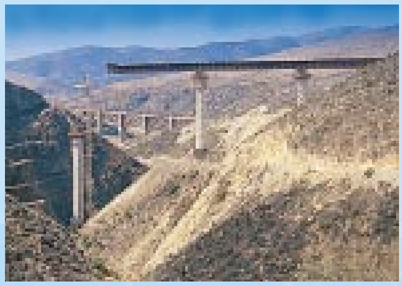
Following several design studies, during which a balanced cantilever bridge was also considered as an alternative, it was finally decided to built a composite steel box structure using a prefabricated post-tensioned deck. The 268-m long bridge is divided in 4 spans (40 m, 60 m, 80 m and 88 m) and its steel box structure is 8 m wide and 4 m high. The deck is a 26-cm thick and 22,7-m wide post-tensioned slab. The piers heights range from 22.6 m to 101 m with a constant section over the main part of the height. Figure 1 shows the bridge elevation and figure 2 the cross-section. The bridge construction required 9,000 m³ of concrete, 735 t of rebar, 2,000 t of steel structure and 80 t of PT.

Construction considerations

The superstructure construction began with the in-situ casting of the piers using the VSL Climbform system while, at the same time, the steel structure was built behind the first abutment. Four launching operations were needed to erect the full length of the deck, from the first span to abutment n°2.

Once the steel box launching was completed, the installation of the prefabricated deck could begin. Two strand jacks, placed on each side of the bridge and mounted on abutment n°1, were used for the launching operation. Figure 3 shows the equipment location at the abutment. The front part of the composite box has a special steel device in order to adjust the bridge to the correct position when reaching the piles.

Two 120-t capacity jacks were used to lift the bridge. Special Teflon bearings were installed over the piles for the bridge sliding operation and a number of lateral steel guides maintained the bridge in position. The sliding operation used 250-t capacity flat jacks.



Located 310 km north of Santiago, the Amalonas viaduct is the first launched bridge structure in Chile.

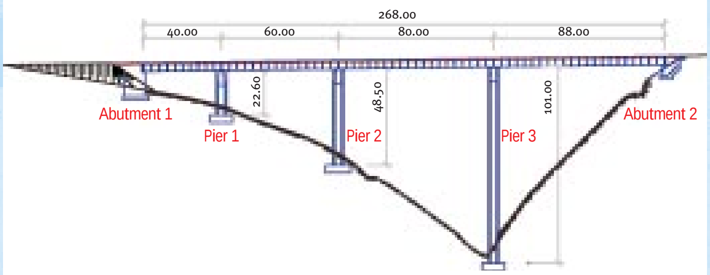


Fig. 1 *General elevation*

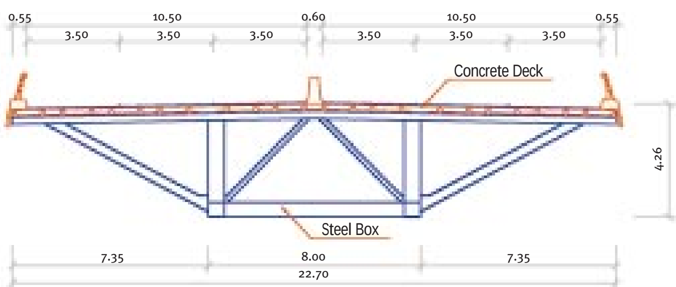


Fig. 2 *Transversal section*

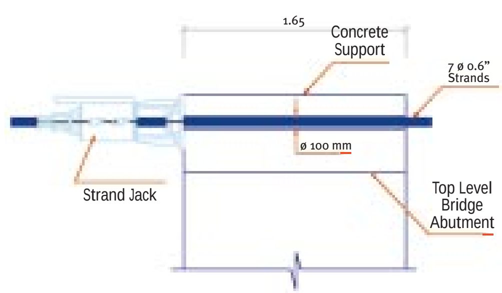


Fig. 3 *Launching jack position*

VSL was involved in this project from a very early stage, assisting Sacyr Chile S.A. in the launching concept and method considerations. Our scope of works included the supply of the bearings, jacks, the equipment and execution of the launching operations, the longitudinal post-tensioning for the deck and the installation of a special displacement joint.

Conclusion

The Amolanas Bridge is the first bridge launching operation in Chile and South America. Thanks to this method, the main contractor was able to considerately reduce cycle times and the bridge was completed in October 2000. As this project introduced new technologies to the country, it was a positive experience for the entire engineer crew involved in the construction. ■

Andres Avendaño
VSL Chile

- HONG KONG -

WEST RAIL CC201/CC211/CC213

Long span continuous balanced cantilever construction utilising cranes for segment erection.

The KCRC West Rail Project involves the construction of a 30-km twin track, heavy rail, passenger line between West Kowloon and the rapidly developing new towns in the NorthWest New Territories.
Starting at grade in West Kowloon, the line runs north to Lai Chi Kok where it goes underground through a series of cut and cover and bored tunnels until it emerges in the Kam Tin Valley where the new depot will be located. From there, the line runs along an elevated dual viaduct for approximately 10 km until it reaches the coastal town of Tuen Mun.

Through a major sub-contract with the MCW JV (KCRC Contracts CC201 & 211) and a smaller sub-contract with the HKACE JV (KCRC Contract CC213), VSL is responsible for 100% of the erection of the pre-cast concrete segmental viaduct.

VSL main section works

Contract	Client	Duration	Spans	Segments
CC201 CC211	Maeda-Chun Wo Joint Venture (MCW JV)	Sept 99 - Aug 01	657	8,600
CC213	HK Construction, AMEC, China Railway, China Everbright JV (HKACE JV)	Jan 01 - Sept 01	42	555

Span-by-span construction using under box girder for erection of multiple parallel decks

The viaducts are being constructed in accordance with an alternative design prepared by Robert Benaim and Associates Asia, which involves single spans fixed to independent piers to utilise portal action.
This design proved to be extremely efficient in terms of material quantities.

VSL's multinational team (over 10 different nationalities) is now well into the project with erection proceeding on ten different fronts using four different types of equipment.
As of the middle of October some 1,400 of the 9,155 segments had been erected and works are expected to progress at an average of 200 segments per week.
Target completion of the erection works is September 2001. ■

Steve Grogan
VSL NEA - Special Projects

VSL multinational site team representing over 10 nationalities

- SINGAPORE -

Telok Blangah Road Upgrading

Telok Blangah is an avenue located at the southern tip of Singapore. It is the main artery linking Singapore harbour, the second busiest harbour in the world, to the island highway network. The Land Transportation Authority (LTA), a statutory board under the authority of the Singapore Ministry of Communications, awarded Hock Lian Seng Infrastructures Pte Ltd, the construction of a 2,445-m long bridge based on a twin box-girder structure (2 x 12.8-m wide). The bridge will carry a dual three-lane carriageway. Its 60 spans, ranging from 40 to 45 m, comprise a total of 1,462 segments, weighing between 45 and 58 t.
Built using the Free Cantilever method, it is a structural frame type bridge, with the spans rigidly connected to the crossheads, and expansion joints installed every seven spans (about 250 m).

Fore-ground: steel work for the erection of the first pair of segments. Back-ground: gantry for the erection of remaining segments.

VSL was awarded a large scope of works including:
- erection of the partially pre-cast crosshead over the centre piers (about 160 t, 28 m long);
- launching of 4 first pair segment units connected to the crosshead and casting of the in-situ stitch;
- supply and operation of the launching gantry for erecting the remaining field segments;
- preparation and casting of the in-situ stitch at mid-span after completion of the cantilevers;
- supply and installation of post-tensioning (1,900 t) for the main bridge and ramps.

This project is a human and technical challenge from all points of view given the site constraints and the complicated nature of the structure.
With a total crew of about 90 persons, the project is organised around 3 daily shifts: night shift for activities requiring lane closures, such as the heavy erection works, afternoon shift for activities involving some night time works such as preparation and casting of the stitches, and day shift for all remaining activities, such as permanent PT.

Technically, the “structural frame”, when compared with a structure built over bearings, leads to complicated PT layouts at the crossheads, where longitudinal PT crosses over the transverse PT. Installation of the first pairs of segments must be carried out with the highest degree of accuracy, the geometry of the full cantilevers being dictated by these first segments, without possibility of adjustment after the stitch casting operations.

Pre-cast crosshead with support frame and pier corbels. Piers corbels are hydraulically equipped to adjust the crosshead monolithic to the pier.

Since no important works are allowed over running traffic, which is maintained at full capacity throughout the duration of the project, launching operations are carried out at night only, when traffic can be disrupted.
Completion of the superstructure erection is scheduled for the middle of 2001.
Finally, traffic is present everywhere and at all times. Restricted working and storage areas enforce multiple relocations and handling of temporary structures and materials, and require a high level of co-ordination between the main contractor, local authorities and other subcontractors. The highest safety levels must also be maintained, not only for the teams directly involved in the works, but also for public safety.

Overall, this difficult and challenging project allows VSL to affirm its leadership in the competitive Singaporean civil construction industry. There is no doubt that it will lead to VSL participating in other projects requiring high degree of competency and engineering in technical civil works. ■

Jean-Marie Laurens
VSL Singapore

CTT Stronghold

Portrait of the VSL Spanish subsidiary

CTT Stronghold's earliest activity in Spain goes back to 1957. At the time, the Spanish subsidiary worked under the name of "Centro de Trabajos Técnicos" and was selling and installing prestressing materials and equipment.

In the early seventies the company developed the Stronghold Multistrand system which was officially presented at the FIP Congress in 1974.
In 1990, when the construction business in Spain was booming due to major investments in infrastructures for the Olympic Games and the 1992 Universal Exposition, Centro de Trabajos Técnicos was bought by Bouygues and its name was changed to "CTT Stronghold S.A".

In 1993 the construction market dropped dramatically. In order to optimise resources, Bouygues decided to merge CTT Stronghold S.A. with VSL Ibérica, thus transferring all the staff to Barcelona.

By joining the VSL Group, CTT became one of the country's main manufacturers and suppliers of PT components, equipment and bearings.

High Speed Railway Viaducts (1997 / 2000)
Since 1997, CTT has been involved in the construction of six incrementally launched viaducts for the HSR linking Madrid to Barcelona. The decks of these double railway track viaducts are concrete single box girders with typical spans of 35 or 42 m.
In addition to the post-tensioning works, CTT supplied the pot bearings, the sliding pads, the launching equipment and the lateral guides, as well as technical assistance.

Viaduct over the Miño River at Orense

Although CTT has a great deal of experience in cable-stayed bridges using the Stronghold system, this viaduct is the first to be built in Spain using VSL stay cable system. Owned by Xunta de Galicia (Regional Government of Galicia), the viaduct construction was awarded to ACS and OCA.
The horizontally curved deck has a 110-m main span and two 20-m high inclined pylons, each supporting 2 x 14 stays in the deck axis.
The 21.7-m wide deck is a double box girder, externally post-tensioned by four 24/0.6" cables but without any adherent post-tensioning.
CTT has already supplied the pot bearings and is currently supplying and installing the PT and the stays (replaceable strand-by-strand) using the Automatic Stressing system.

In January 1998, it became the first post-tensioning sub-contractor to obtain ISO 9002 certification in Spain. In May 1998, CTT developed its ground anchors activity (strands and bars) through a new company, VSL-SPAM.

Since 1994, the VSL Group has continued to develop in Spain and its turnover has increased constantly from USD 3.5 million in 1993 up to a forecast USD 10 million for 2000. This situation is both due to the upturn in the Spanish economy over the past few years and the major effort made by CTT's staff to improve its core business (post-tensioning, pot bearings and elastomeric bearings) and develop new activities such as retained earth, ground anchors and bars, heavy lifting and special equipment, etc.).

The projects presented here summarise the commitment of CTT and the VSL Group to improve the quality of products and services and target new business opportunities to ensure CTT's leading position in Spain as a specialised sub-contractor for post-tensioning and related activities. ■

Enrique Alonso
CTT Stronghold

Ground Anchors for the Liceo (Opera House) in Barcelona

Following the disastrous fire that destroyed the old Liceo Building, it was decided to build a new Opera House on the same location.
The foundation works were awarded to Dragados and OSHSA. Major excavations were required to incorporate the very sophisticated stage movement equipment. Consequently, the surrounding walls had to be anchored by means of a large quantity of permanent and semi-permanent ground anchors, supplied and stressed by CTT.
In addition, CTT also supplied a small quantity of load cells for the ground anchor control and survey operations.

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