Bridge Construction Partner

Precast Segmental Construction
Insitu Construction
Heavy Lifting
Stay Cable Construction
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**Sungai Johor - Malaysia** (2006-2009)

**Gautrain - South Africa** (2008-2010)

**North Arm Canada Line - Canada** (2006-2008)

**La Unidad Bridge - Mexico** (2002-2003)
From Post-tensioning to Bridge Construction Partner

VSL is recognised as a world leader in specialist construction engineering and associated technologies and services. Today, VSL operates as a network through 50 locations established on 6 continents. VSL provides a full range of technical and construction services for bridge construction, including design evaluation, permanent works design, temporary works design and construction engineering, precasting management and bridge construction.

Innovative solutions worldwide

VSL has contributed to some of the most prestigious and complex bridge structures around the world, ranging from large span stay cable bridges to conventional precast beam bridges. References include: the first full span bridge in Ductal® (Seonyu Footbridge, Korea, 2001), Shenzhen Western Corridor, Hong Kong (2006), with a new lifting frame for balanced cantilever construction, allowing construction of twin decks simultaneously, the Stonecutters Bridge in Hong Kong (2008), a most complex heavy lifting operation for one of the longest stay cable bridges in the world, the Gateway Bridge duplicate in Brisbane, Australia (2009) where VSL has implemented new form travellers allowing prefabrication of the web reinforcement, fast track erection of bridge segments on the Light Rail Transit in Dubai (2009), the bridges on the Gautrain railway, South Africa (2010), the Baluarte Stay Cable bridge, Mexico (2010), with the highest main span worldwide.

VSL has evolved from a specialist post-tensioning company into a multi discipline bridge partner, capable of providing contractors and engineers with construction and engineering services for highly complex and demanding projects. More importantly, the localised organisation of VSL provides clients with innovative practical designs and construction solutions adapted to suit the local market.

Promoting highly efficient rates of construction

With extensive experience in large infrastructure and superstructure projects, VSL has a proven record of developing project-specific construction systems and methods that promote highly efficient rates of construction and facilitate programme surety, while maintaining and always enhancing essential safety and quality control measures.

Lateral thought processes encouraged within the design and production teams provide a suitable environment in which to nurture novel, and often remarkably simple solutions to demanding problems. The exchange of knowledge within the VSL global network enables the group’s considerable experience to be fully utilised and applied in a wide variety of engineering domains.

As a specialist bridge partner, VSL can bring the project team an extensive experience gained from erecting over 100,000 precast bridge deck elements (providing almost 5 million square meters of bridge surface), constructing multiple in-situ bridges utilising VSL form travellers and incremental launching methods and also being involved in the construction of over 150 stay cable bridges.

VSL is committed to offering clients the ‘best for project’ service that has recently led to the development and implementation of various innovative Partnering and Alliancing arrangements that have proved to be highly successful and mutually beneficial to all parties.
VSL’S TURNKEY SERVICES

From the very early concept design all the way through to the project’s handover and beyond, VSL is working closely with its customers. Owners require the most suitable project completed as quickly as possible in the most economic and durable manner. Contractors need feasibility studies to establish the most efficient and cost-effective building solution.

<table>
<thead>
<tr>
<th>Define</th>
<th>Optimise</th>
</tr>
</thead>
</table>
| **Choice of construction methods based on local environmental and economic constraints**  
  • Structure type and the temporary works required  
  • Project timeline  
  • Cost comparisons for budgeting  | **Structural principles**  
  • Selection of locally available materials  
  • Outlined construction methods and definition of temporary works  
  • Detailed design of permanent structure, taking account of the construction methods  
  • Integrated workshop drawings |

**VSL provides**

- Conceptual permanent substructure and superstructure design works in conjunction with consultants
- Material quantities and specifications, defined in conjunction with consultants
- Superstructure construction methodology, assessment of temporary works and special equipment requirements
- Superstructure construction sequence and programme
- Preparation of superstructure construction cost estimates for budgeting
- Preparation of outline superstructure safety and quality control plans
- Preparation of outline superstructure project management plans

**VSL provides**

- Collaboration with the permanent works designer for superstructure design and rationalisation
  • Construction engineering
  • Geometry control
  • Leadership in the temporary construction works
  • Assistance to designers in making the structure easy and efficient to build, including reviewing the small details that will ease construction
  • Defining and designing the temporary works and special equipment required, including assessment of their impact on the permanent structure
  • Integrated workshop drawings for fabrication of the superstructure
  • Incorporation of the post-tensioning with all associated design and detailing
  • Detailed methods of construction
  • Design of temporary works associated with precast yard and moulds
VSL provides

**Deliver**

- Design of erection equipment with the performance to meet the programme and the specifications
  - Fabrication of temporary works
  - Set-up and management of precasting areas
  - Mobilisation of highly qualified staff
  - Management of the construction project

- Building the project quickly, efficiently and at the lowest cost possible
  - Mobilisation of an experienced project team for superstructure construction, capable of site assistance up to the level of overall site management
  - Implementation of strict safety/QA/QC standards for building the superstructure
  - Implementation of operating permits for major equipment
  - Supply of temporary works associated with the precast yard and moulds
  - Supply and operation of the temporary works associated with superstructure construction
  - Effective site logistics control for superstructure construction
  - Effective communication and coordination with the various entities associated with the superstructure construction
  - Fast-track problem solving
  - Project control procedures to ensure superstructure delivery according to schedule and specification

**Maintain**

- Monitoring of the structure
- Periodic maintenance
- Strengthening if required
- Repairs on demand

- Monitoring the behaviour and aging of the structure, to anticipate repair costs and to keep maintenance activities and their impact on the structural operation to a minimum
  - Defining and planning the most suitable monitoring scheme and its budget for installation and implementation
  - Supply of hardware and software for monitoring the structure
  - Training the client and handing over the system
  - Inspection of the structure when required and issuing reports
  - Proposal of repair or strengthening plans if required
  - Implementation of repair and/or strengthening plans as required
Safety first

VSL’s construction projects for bridges and other structures involve the operation of major items of machinery, which are usually designed or adapted to meet the specific conditions and constraints of each particular project. This means that VSL’s equipment is usually complex and one-of-a-kind, controlled by multiple operators. It therefore requires a high level of preparation, engineering, coordination and skills to ensure its safe and efficient operation.

MEOP – a license to operate

To improve safety and efficiency, the in-house operating permit system MEOP (major equipment operation permit) is compulsory on all VSL projects using major equipment.

The permit system is based on the following principles:
- Design review process that includes an external and independent checking engineer
- Review of the project set-up in terms of methods, procedures, checklists, hold points, emergency preparedness, health and safety
- Review of organisational and back-up plans as well as training and qualifying of key staff, with written tests designed to assess understanding of risks and procedures
- Review of fabrication and quality control of the equipment
- Review of the equipment assembly and commissioning
- Review of all critical operations
- General site review

Permits are granted by a panel of independent internal auditors at the conclusion of a site audit carried out to review all of the above aspects, checking safety, quality, technical and operational issues.

Permits are generally valid for a period of six months and are renewed then or at any time when there is a change on the project such as construction methods, organisation and equipment.

Health and safety

VSL’s top priority is the health and safety of its workforce and everyone else potentially affected by its activities. VSL’s approach meets international standards and routinely goes beyond local requirements and expectations on all its construction sites worldwide. The whole VSL Group adopts this attitude. Worldwide safety days are organised within the network with the aim of improving safety awareness and standards.

Although projects are supported by strong safety teams, all VSL staff members are also well aware that safety is a vital concern.

All employees actively participate in the creation of a safe working environment by proactively identifying and communicating any concerns encountered on the job. All employees are given the authority and responsibility to stop what they are doing and address the situation if they feel it compromises safety.
Encouraging development of employees’ skills

VSL demanding projects and the highest requirements in terms of quality of service reflect themselves in a resolutely proactive training organisation within the company. The continuous development of VSL's staff is a key factor for excellent performance. It is thus vital to properly manage competences internally at all levels and to structure and formalize the training accordingly.

Back to basics: the VSL Academy, dedicated for training site staff

The transfer of knowledge and acquired experience by senior staff to new staff members used to be one of the ways to pass on not only the technical details but also the company’s culture and values. Given the evolution in recent years, this intergenerational transfer is no longer guaranteed throughout the ever growing network. It has thus been decided to create the VSL Academy, a unique Post-tensioning training centre in Bangkok that has been created to tackle this challenge.

To enable hands-on practical training, post-tensioning mock-ups have been built on the Academy’s premises and further mock-ups are being designed to cover other appropriate operational procedures.

The training sessions are given by experienced staff and the access to the various levels is stringent: a written exam has to be successfully passed to fulfill the requirements in stage certification. Before being admitted to the next level, the participants have to be involved in Post-Tensioning works for a minimum of one year.

Training for Excellence: the PMX / GMX program

VSL launched its PMX (Project Manager Xcellence) training program in 2006 to develop the capability of Project Managers to take on major projects and manage the operational side of the business. The objective is to improve their knowledge and objective management capabilities.

On the basis of these training courses, GMX (General Manager Xcellence), a new program, focuses on corporate issues, rather than only project specific ones. GMX is designed to develop the skills of VSL Managers, in particular leadership and personal development; to prepare high potential staff for future management positions. GMX runs alongside the existing PMX program as part of VSL's overall staff development plan.
VSL has over 20 years experience in the design and construction of precast segmental balanced cantilever bridges. VSL in-house technical centres are primarily involved in the design of erection systems and associated temporary works, and have also completed many permanent works designs in close cooperation and conjunction with Designers and Consultants. VSL has the capability and necessary experience to work with designers and contractors to develop cost effective designs that promote safe, effective construction sequences and methods while achieving optimal productivity. VSL is recognised as a world leader in precast segmental erection and has worked extensively with international contractors on technically demanding projects. VSL's highly efficient erection systems enable contractors to...
LAUNCHING GANTRY

FEATuRES & ADVAnTAGES

• Delivery of segments along completed deck to rear of gantry minimises disruption to existing traffic networks.

• Necessary temporary works require little ground improvement and are generally elevated, therefore causing minimal disruption to existing roads, structures or services.

• Support craneage is reduced due to temporary works being relocated by gantry.

• Clear, unobstructed access to all work fronts is provided within gantry system.

• Work can proceed on multiple work fronts within the gantry, i.e. pier segment erection, cantilever construction and closure pour construction.

• Temporary loads are introduced directly into piers.

• Fast rates of erection are possible (up to 6 pairs of segments per shift are regularly achieved by VSL).

minimise construction durations while optimising quality. VSL regularly achieves production rates exceeding one cantilever per week.

Within the VSL organisation, there is an extensive network of project managerial, technical and production staff.

Second Gateway Bridge - Australia (2008-2010) 29,526m² of deck, 700 precast elements

Lai Chi Kok - Hong Kong (2004-2006) 63,000m² of deck, 1,771 segments

Shenzhen Western Corridor - Hong Kong (2004-2005) 90,800m² of deck, 1,879 segments

Waiwera Viaduct - New Zealand (2007-2008) 12,130m² of deck, 356 pre-cast segments

Shatin T3 - Hong Kong (2004-2007) 65,800m² of deck, 1,806 segments

Pakse Bridge - Laos (1998-2000) 16,284m² of deck, 384 segments

Typical Erection Cycle

<table>
<thead>
<tr>
<th>Description</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<tbody>
<tr>
<td>Span N-1</td>
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<tr>
<td>Curing of Stitch (Overnight)</td>
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<tr>
<td>Continuity P.T.</td>
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<tr>
<td>Span N</td>
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<tr>
<td>Launch Gantry to Span N</td>
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<tr>
<td>Segment Erection Span N</td>
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<tr>
<td>Stitch N to N-1</td>
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<tr>
<td>Span N+1</td>
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<tr>
<td>Erect Pier Segment</td>
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<tr>
<td>Align Pier Segment</td>
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<tr>
<td>Place Reinforcement</td>
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<tr>
<td>Place Formwork</td>
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<tr>
<td>Cast In situ Diaphragm</td>
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<tr>
<td>Curing Pier/Column Joint</td>
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Duration: 6 Shifts
VSL has been involved in an extensive number of span-by-span precast segmental projects in the Asia region and has recently completed large segmental infrastructure projects in South America and the Middle East. Often in the face of demanding design, program and site constraints, VSL has a proven ability to provide Consultants, Engineers and Contractors with innovative, practical and cost effective solutions, proving to be mutually beneficial to all parties involved.

VSL erection systems are developed to optimise permanent works design and minimise additional temporary works required during the construction stage. Within the VSL network, an extensive pool of suitably qualified personnel is available to manage, supervise and operate the high capacity erection gantries. Generally, in support of the production teams, each
Gantry

Features & Advantages

- Flexibility to use overhead or underslung gantries.
- Fast rates of erection are possible due to use of external post-tensioning (VSL has achieved rates of erection exceeding 1 span every 24 hours).
- Segment delivery is possible along completed deck to rear of gantry or at ground level.
- Smaller crew size is required compared to balanced cantilever construction.
- Good access provided within the gantry to all work fronts.

Light Rail Transit Dubai - UAE (2007-2009)
430,000m², 16,450 segments

Deep Bay Link - Hong Kong (2004-2005)
108,000m² of deck, 3,014 segments

West Rail - Hong Kong (1999-2002)
116,667m² of deck, 8,642 segments

Bandra Worli - India (2002-2006)
132,130m² of deck, 2,332 segments

Penny’s Bay - Hong Kong (2003-2004)
16,240m² of deck, 627 segments

Bangalore Hosur Elevated Expressway - India (2006-2008) 9.5km of elevated deck

Regular erection rates achieved are 1 span per 2.5 days with underslung gantries, and 1 span per 4 days with overhead gantries. Being allowed to operate 24-hour a day, VSL recently achieved in Chile a typical erection cycle of 1 span every 24 hours.

<table>
<thead>
<tr>
<th>Typical Erection Cycle</th>
<th>Duration: 4-Day Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>1</td>
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<tr>
<td></td>
<td>D/S</td>
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<tr>
<td>Launching of Gantry</td>
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<tr>
<td>Segment Placing</td>
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<tr>
<td>Segment Alignment / Gluing</td>
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<tr>
<td>Wet Joint Casting</td>
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<tr>
<td>Curing (Overnight)</td>
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<tr>
<td>Installation of External P.T.</td>
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<tr>
<td>Stressing of External P.T.</td>
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</tbody>
</table>
VSL continually develops innovative lifting solutions applicable to precast segment erection. VSL strand lifting units, incorporating multiple safety features are regularly utilised, providing a large range of lifting capacities whilst allowing precise alignment and placement of segments. Extensive studies conducted by VSL’s technical centres facilitate the development of project specific lifting systems. Precast element delivery usually governs the method adopted and VSL have successfully operated lifting frames suitable for use on projects with considerable delivery constraints. VSL lifting frames are self-contained and incorporate safe unobstructed working platforms and accesses to all necessary locations. Following assembly, installation and commissioning by suitable cranes, VSL
LIFTING FRAMES

FEATURES & ADVANTAGES

- Relatively simple temporary works requirements.
- High rates of erection.
- Large segments can be erected.
- Optimised crew cycles.
- Multiple levels of segment alignment and adjustment are possible.
- Strand lifting units can be adopted and provide several levels of safety features.
- Deck construction does not have to be linear, but can be sequenced to follow pier construction.

Serembam Middle Ring Rd 2 - Malaysia (2008-2009) 12,196m² of deck, 481 precast elements

Lai Chi Kok - Hong Kong (2004-2005) 63,000m² of deck, 1,771 segments

Quarashia Bridge - Saudi Arabia (1989-1990) 12,820m² of deck, 143 segments

Kisosansen Bridge - Japan (1998-2001) 90,000m² of deck, 344 segments

Shenzhen Western Corridor - Hong Kong (2004-2005) 90,800m² of deck, 1,879 segments

Lifting frames can operate independently. VSL lifting systems incorporate two primary hydraulic systems providing both lifting and self-launching mechanisms. When high lifting speeds are required, generally greater than 20 meters per hour, tandem lifting units or winch systems have been utilised.

VSL technical centres typically work with engineers to incorporate necessary lifting system tie down into the permanent works, to ensure suitable load introduction into the permanent works and also provide stage by stage analysis, geometry control and precamber calculation. VSL’s experienced supervisory teams regularly achieve erection cycles of two pairs of segments per shift.

Hanger Beams

1st pair of field segments erected by crane. Segments are suspended from hanger beams or lifting frames when there is a wet joint.

Pier Segment Erection by Crane

<table>
<thead>
<tr>
<th>Typical Erection Cycle</th>
<th>Duration: 13 Shifts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>1 2 3 4 5 6 7 8 9 10 11 12 13</td>
</tr>
<tr>
<td>Erect &amp; Assemble Lifting Frames &amp; Brackets on Pier Head</td>
<td></td>
</tr>
<tr>
<td>Segment Erection - Pair 1</td>
<td></td>
</tr>
<tr>
<td>Wet Joint Construction</td>
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<tr>
<td>Wet Joint Curing</td>
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<tr>
<td>Segment Erection - Pair 2-3</td>
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<tr>
<td>Segment Erection - Pair 4-5</td>
<td></td>
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<tr>
<td>Segment Erection - Pair 6-7</td>
<td></td>
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<tr>
<td>Segment Erection - Pair 8-9</td>
<td></td>
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<tr>
<td>Segment Erection - Pair 10-11</td>
<td></td>
</tr>
<tr>
<td>Segment Erection - Pair 12-13</td>
<td></td>
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<tr>
<td>Remove Lifting Frames</td>
<td></td>
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</tbody>
</table>
Erection using suitable mobile craneage has frequently been executed by VSL, particularly in relation to balanced cantilever construction. When site and ground conditions are suitable, this method of erection has proved highly effective and can facilitate considerable rates of erection.

VSL project teams provide detailed craneage studies helping to optimise crane usage while minimising disruption to the surrounding environment. In particular, VSL has assisted contractors to develop and implement temporary traffic management schemes. VSL technical centres work with production team to develop additional temporary works, in particular pier segment supports and access requirements. VSL is capable of offering stage-by-stage analysis and detailed precamber calculation. With careful project design and management, cranes of varying types and capacities have been utilised by

West Rail - Hong Kong (1999-2002) 8,330m² of deck, 617 segments
CRANES

FEATURES & ADVANTAGES

- Temporary works requirements are minimised.
- Fast rates of erection are possible.
- Multiple work fronts are possible.
- Optimised crew size.
- Minimal engineering requirements.
- Cranes are generally readily available in the market.
- Cranes can be utilised to execute other activities.
- Deck construction does not have to be linear, but can be sequenced to follow pier construction.

VSL to achieve the best operating results. Typical erection rates are up to 6 segments per day.

**Typical Erection Cycle**

<table>
<thead>
<tr>
<th>Description</th>
<th>Duration: 8 Shifts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation of Pier Segment Support Brackets</td>
<td></td>
</tr>
<tr>
<td>Installation of Pier Segment</td>
<td></td>
</tr>
<tr>
<td>Segment Erection - Pair 1-3</td>
<td></td>
</tr>
<tr>
<td>Segment Erection - Pair 4-6</td>
<td></td>
</tr>
<tr>
<td>Segment Erection - Pair 7-9</td>
<td></td>
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<tr>
<td>Segment Erection - Pair 10-12</td>
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</tbody>
</table>
VSL has considerable experience in the erection of various precast beam structures. Methods of erection have been developed following extensive studies relating to site constraints. Generally, the delivery of precast beams to the erection front is the determinant that influences the method of erection system to be adopted. VSL has utilised a variety of launching girders, beam launchers and lifting frames, capable of receiving precast beams directly behind, below or in parallel to the erection system. I beams, U beams and T beams have been erected extensively.

In addition to the erection of primary structural members, VSL has also been responsible for the complete construction of bridge decks including placement of precast planks, and insitu works. VSL’s experienced project specific management, supervisory and technical teams facilitate...
FEATURES & ADVANTAGES

- Fast rates of erection.
- Relatively simple erection gantry, or crane erection.
- Beam delivery possible along completed deck to rear of gantry, thus minimising disruption to existing traffic networks.
- Small works crew size.
- Geometry control is minimised.
- Precast beam production is relatively simple and requires low levels of mechanisation.

Typical Erection Cycle:

**Description**: Lift and place 1st beam (outer most) with precast plank on top
**Duration**: 2-Shift Cycle (Hours)

<table>
<thead>
<tr>
<th>Shift 1 (10 Hour Shift)</th>
<th>Shift 2 (10 Hour Shift)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lift and place 1st beam with precast plank on top</td>
<td>Lift and place 2nd beam with precast plank on top</td>
</tr>
<tr>
<td>Lift and place 3rd beam with precast plank on top</td>
<td>Lift and place 4th beam with precast plank on top</td>
</tr>
<tr>
<td>Reposition the intermediate planks into final position</td>
<td>Move gantry to center viaduct then launch to next span</td>
</tr>
</tbody>
</table>

Palau Island Bridge - Palau (2003-2005) 4,000m² of deck, 52 beams

Cebu Coastal Road - Philippines (2001-2002) 24,000m² of deck, 320 beams

Sarasin Bridge - Phuket, Thailand (1991-1992) 7,800m² of deck, 182 beams

East Coast Parkway - Singapore (1981) 68,250m² of deck, 180 beams

Tutong Lumut Coastal Highway - Brunei (2001-2003) 6,100m² of deck, 210 beams


Rates of erection often exceeding one span per day. With the precast beam method, strand and winch lifting units are utilised, providing safe and precise placement of precast elements, allowing multiple degrees of alignment and efficient rates of erection.

Tandem lifting of full span precast beams with cranes has also been adopted facilitating the lifting of large loads often exceeding 100 tonnes in weight and 40m in length.

![Diagram of front support leg](Image)
The full span precast method of erection is particularly suited to projects comprising multiple spans of similar length which have minimal horizontal radii. Typically rail networks are most suitable for this method of erection. VSL has considerable experience in this field of erection, with specific references including the Taiwan High Speed Rail Project and the Singapore MRT.

Full span precast elements can be constructed in a static casting yard under factory conditions which facilitate improved safety and quality while also optimising labour and necessary plant requirements. Other than access to the pier heads, very little temporary works are required and follow up activities are minimised. Rapid rates of erection are achievable, and VSL has obtained erection rates of up to 2 spans per day with one launcher. Delivery
of precast elements along the completed deck reduces disruption to existing traffic networks and helps minimise ground improvement works that would otherwise be required to transport large elements at ground level.

FEATURES & ADVANTAGES

- Very high rate of production, with very high quality.
- Minimal follow up works.
- Full span production in factory environment allows improvements in quality of precast elements.
- Delivery of elements to rear of gantry is possible along completed deck therefore minimising disruption to existing traffic networks.
- Reduced on site activities, improves safety and environmental concerns.
- Minimal additional temporary works are required.
VSL has adopted the falsework support method on many precast segmental projects. Dependent upon the imposed loading and the effective height, conventional scaffold support or heavy shoring systems are utilised. Hydraulic systems are incorporated to enable temporary segment support, alignment and load transfer onto piers. Typically, segments are loaded onto the falsework support using suitable craneage. However, if access is limited, VSL has also developed alternative solutions for the handling and loading of segments. VSL engineering and production staff conduct extensive logistic studies relating to site access, segment handling and temporary foundation needs. Modular support systems are adopted to minimise relocation durations and to optimise erection rates. Long span support structures are often developed to

Deep Bay Link - Hong Kong (2004-2005)
108,000m² of deck, 3,014 segments
**Features & Advantages**

- Minimised engineering requirements are possible.
- Modular support system can be relocated with ease and relatively quickly.
- Work can proceed on multiple work fronts.
- Production crew size is fully utilised and optimised.
- Good access is provided to all work fronts.

**Form Traveller Form System Stay Cable**

**Heavy Lifting**

**Description**

1. Installation of Scaffold Support
2. Erection of Segments
3. Alignment and Gluing
4. Post Tensioning Operations
5. Load Transfer onto Permanent Bearings

**Typical Erection Cycle**

<table>
<thead>
<tr>
<th>Description</th>
<th>Duration: 4-Day Cycle (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation of Scaffold Support</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Erection of Segments</td>
<td></td>
</tr>
<tr>
<td>Alignment and Gluing</td>
<td></td>
</tr>
<tr>
<td>Post Tensioning Operations</td>
<td></td>
</tr>
<tr>
<td>Load Transfer onto Permanent Bearings</td>
<td></td>
</tr>
</tbody>
</table>

**West Rail - Hong Kong (1999-2002)**
116,667m² of deck, 8,642 segments

**Penny’s Bay - Hong Kong (2003-2004)**
16,240m² of deck, 627 segments

**Deep Bay Link - Hong Kong (2004-2005)**
108,000m² of deck, 3,014 segments

**Penny’s Bay - Hong Kong (2003-2004)**
16,240m² of deck, 627 segments

**West Link - Australia (2004-2005)**
86,000m² of deck, 3,013 segments

**East Rail - Hong Kong (2000-2003)**
58,320m² of deck, 4,449 segments

cater for road or rail crossings. Support structures incorporate access and working platforms and may include suspended containments to manage falling debris. Typical erection rates are up to one span every three days.
The principle of the incrementally launched bridge consists of building the superstructure segments in a casting yard located behind the bridge abutment. Each segment is matchcast against the previous one and prestressed to the section of superstructure already built. The entire superstructure is then jacked forward a distance equal to the length of this segment. This process is repeated until the bridge is in its final position. Additional continuity prestress is then installed and the temporary bearings are replaced by the permanent bearings. This form of construction can be used for bridges having constant cross sectional shape throughout their length. The bridge should be straight or have constant horizontal and vertical curvatures. The incrementally launched bridge has several advantages. It eliminates the traditional scaffolding required for supporting
**FEATURES & ADVANTAGES**

- Concentrated work front optimises craneage requirements.
- Site constraints such as poor ground conditions or ground traffic restriction can be minimised.
- Minimal temporary works.
- Seven-day cycle is achievable if overtime is allowed.
- Require only a moderate investment in specialised equipment such as launching nose, launching jacks, conventional jacks, launching bearings and guides.

---

**TYPICAL CONSTRUCTION SEQUENCE**

1. Cast segment (A), install launching nose, install pulling units
2. Pull segment (A) forward using pulling jacks attached to reaction beam
3. Construct segment (B), repeat stage 1 and 2 for remaining segments

---

**TYPICAL CONSTRUCTION CYCLE**

<table>
<thead>
<tr>
<th>Description</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launch Segment</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strip and Clean Forms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Install Base and Web Rebar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Install Web Forms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete Base and Webs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Install Inner Forms</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Install Top Slab Rebar</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete Top Slab</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stress P.T.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Typical Construction Cycle Duration: 8-Day Cycle (Days)
Developed from VSL's earlier form traveller systems, VSL has produced a standardised modular form traveller system, applicable to most contemporary bridge designs. This highly flexible system allows efficient and repeated use on bridges with different cross sections. A variety of casting lengths can be adopted to suit engineers’ designs. Mechanical and hydraulic systems built into the form traveller system ensure precise control of the bridge during construction. The lightweight modular system requires minimal support craneage during assembly, erection and relocation.

Unobstructed working platforms and access are incorporated into the form system. Reinforcement and concreting operations have been optimised by minimising obstructions caused by the form traveller. Typical cycles of 5 days per pair of segments.
**FEATURES & ADVANTAGES**

- VSL modular form travellers are readily available and can be obtained quickly without major re-engineering required.
- Long-span bridge structures with access constraints can be easily accommodated.
- Craneage capacity requirements are minimised.
- Crew efficiency between 1 pair of form travellers is optimised.
- Deck construction does not have to be linear, but can be sequenced to follow pier construction.

<table>
<thead>
<tr>
<th>Bridge Name</th>
<th>Location</th>
<th>Span</th>
<th>Cantilevers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baluarte Bridge</td>
<td>Mexico (2010)</td>
<td>1000m</td>
<td>1000t</td>
</tr>
<tr>
<td>H-3 North Halawa Valley Viaduct</td>
<td>Hawaii</td>
<td>48m</td>
<td>15</td>
</tr>
<tr>
<td>Sinu Bridge</td>
<td>Columbia (2005)</td>
<td>150m</td>
<td>2</td>
</tr>
<tr>
<td>Ma Wan</td>
<td>Hong Kong (1999)</td>
<td>48m</td>
<td>15</td>
</tr>
<tr>
<td>Chenur Bridge</td>
<td>Malaysia (2002-2004)</td>
<td>140m</td>
<td>7</td>
</tr>
<tr>
<td>Radès la Goulette Bridge</td>
<td>Tunisia (2006-2009)</td>
<td>120m</td>
<td>3</td>
</tr>
</tbody>
</table>

Typical Construction Cycle

<table>
<thead>
<tr>
<th>Description</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Removal of stop end form and form ties</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Installation of strand</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Stressing of cantilever P.T.</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Stripping of outer, inner, bottom form</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Launching and fixation of rail beam</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Launching and fixation of main frame</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Cleaning of form panels</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Rolling back of inner web forms</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Adjust / Close outer and bottom forms</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Placing P.T. ducts / inserts for bottom slab / webs</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Launch inner web forms, adjust / close inner web forms</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Placing reinforcement / P.T. ducts / insert for upper deck and cantilever wing</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Final survey / check of level / alignment</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Pour concrete</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Curing - Traveller #1</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Curing - Traveller #2</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>

Duration: 5-day cycle, 12 hours per day
VSL has considerable experience in a wide variety of insitu form system ranging from self climbing form systems utilised for pier and pylon construction to large span underslung movable scaffold support systems. To complement any precast erection operation, VSL is also able to provide detailed design, supply and operation of precast cells required for precast segmental bridge decks, precast beams, and also full span precast elements. Recently, on the Taiwan High Speed Rail Project, VSL was responsible for the complete establishment and operation of the casting yard including reinforcement and concreting operations. VSL form systems are generally modular, light weight and provide clear unobstructed access to all necessary working areas. Mechanised VSL Form Systems facilitate casting of highly complex structures with...
variable geometric properties, and produce high quality finishes often required by clients. VSL managed casting yards regularly achieve precast segmental production rates of up to one segment per day, per cell. The VSL Climb Form System will generally achieve an optimal cycle of three days per four meter lift, however, due to the modular arrangement of the system, variable lift heights can be accommodated with relative ease up to a maximum lift height of six meters.
For economic or technical reasons, today’s bridge structures are often assembled from large, heavy, pre-fabricated elements. For projects in which cranes or other conventional handling equipment cannot be used because of excessive weight, dimensions or space limitations, VSL Heavy Lifting will often provide the most effective solution.

VSL Heavy Lifting provides contractors, engineers and owners with a broad range of advantages, including:

- Economy and efficiency, through custom designed solutions.
- Reliability, based upon sound engineering and three decades of experience.
- The highest level of safety through the use of advanced and reliable hydraulic equipment.

Unique Solutions
VSL will plan lifting, horizontal jacking, or lowering operations and design the necessary temporary structures to suit the requirements of the projects. Sound engineering, clear thinking, the ability to innovate, and years of successful experience provide a guarantee of reliable and cost-effective solutions.

Safety
The safety of personnel and components are VSL’s first priority. Specialised hydraulic lifting equipment is designed for the highest level of reliability, and all equipment is rigorously tested and serviced through VSL’s quality control and maintenance program. VSL field services are also based upon a total commitment to safety.

The extensive experience of VSL personnel and VSL’s exceptional track record provide further assurance of reliable performance.

Flexibility
VSL’s range of equipment provides the capability to lift or lower single loads well in excess of 10,000t and includes a large range of hydraulic jacks, pumps, controls units, monitoring devices, and modular lifting/jacking frames. Thus, VSL has both the capability and flexibility to perform virtually any project requiring lifting, lowering or horizontal jacking.

The VSL Service Package
VSL offers a complete range of services for the planning, engineering, equipment supply and execution of any heavy lifting project. VSL Heavy Lifting services provided throughout the world include:

---

**Stonecutters Bridge - Hong Kong (2007-2009)**
Lifting and shifting of pier table segments and simultaneous lifting of a double deck span of each pylon.
CONSTRUCTION

Infiernillo II Bridge - Mexico (2000)
Lifting of 3 arched steel trusses (600t each)

Industrial Ring Road - Thailand (2005-2006)
Lifting of 500t bridge deck segment

Sheik Zayed Bridge, Abu Dhabi - UAE (2009)
Turning and lifting bridge segments to final position.

Hochdonn Railway Bridge - Germany (2006)
Lowering of the steel structure (1.465t, lifting and tilting operations).

Gessnerbrück - Switzerland (2006)
Sliding of Bridge 3’500t for 23m

Loire River Bridge - France
Lifting of centre span (2,400t)

Serebryany Bor-Moskau-Ru Bridge - Russia (2008)
VSL Heavy lifting units with hydraulic pumps and strands

Features & Advantages

- Economy and efficiency through custom designed solutions.
- Suitable for any heights and any loads.
- High level of safety as load is always secured mechanically.
- Reliability based on 35 years of solid experience.
- High flexibility with lifting units from 10t to 600t capacity.
- Lifting levels and loads with extremely tight tolerances are monitored and maintained with highly precise computer-aided control system.
- Very high capacity to the selfweight ratio.

Feasibility studies and preliminary consultation for lifting, horizontal jacking and lowering operations.

Project design and planning, equipment specification, scheduling and budgeting.

Design, manufacture and supply of special equipment and temporary structures, if required.

Leasing and operation of VSL equipment and execution by VSL or others.

The planning of a heavy lifting operation should be started as early as possible. Early involvement of VSL specialists will result in a handling scheme that optimises the project’s economy, efficiency and schedule.
The VSL SSI 2000 Stay Cable System is acknowledged as being one of the leading systems currently available worldwide. The system is based around the proven VSL strand and wedge anchorage technology and is designed to meet the most stringent criteria offering high fatigue resistance, excellent corrosion protection, easy monitoring and maintenance. Installation and replacement is carried out using strand by strand method which has the benefit of requiring very little space and which utilises relatively light weight equipment. In the basic configuration the system incorporates greased and sheathed monostrands contained within a continuous external HDPE stay pipe, with no grouting in the cable. Additional enhancements can be offered including; metalisation (galvanising) of the monostrands for additional corrosion protection, coloured HDPE stay pipes, etc.
helical ribbing on the stay pipes to reduce risk of wind rain induced cable vibrations, and the VSL Fricton Damper one of the most efficient and robust forms of cable damping available.

In addition to the design, supply and installation of the stay cable system, VSL is able to offer clients a full range of specialist bridge construction services from stage by stage construction analysis to the actual construction of the entire superstructure including the design and supply of the necessary temporary works and construction equipment.

FEATURES & ADVANTAGES

- High fatigue resistance.
- Full encapsulation of strand inside the anchorage.
- Factory applied individual protection treatment, up to 100 years design life in the most aggressive environments.
- Compatible with modern construction methods; compact anchorages fully prefabricated in workshop, single strand installation with light equipment, easy force monitoring and adjustment.
- Faster installation and erection cycles, reduced maintenance.
- Designed to receive in the future vibration damping systems if necessary.
- Ability to remove and to replace individual strands if necessary.
- In some cases, the SSI 2000 Saddle can replace the anchorage in the pylon, easing considerably its detailing and construction.
For VSL, sustainable construction means changing the way we do business: providing ever safer methods of construction and design, using methods and technologies that require less virgin material and less energy, while mitigating pollution and waste. VSL aims to produce schemes that ultimately require less maintenance and are easier to recycle, yet still achieve the required quality.

Many of VSL’s systems and technologies are already contributing significantly to that target. VSL however does not limit the effort to construction techniques but also strives to improve every aspect of its activities for the benefit of all, and particularly for VSL clients concerned with such issues.

Each project presents unique challenges and, in recognition of this, members of VSL’s technical staff work with contractors, owners and engineers to evaluate projects and determine optimal solutions. VSL’s Technical Centres in Asia and Europe help the group around the world to save large amounts of new fabricated steel by recycling existing erection equipment for subsequent use on other bridge and viaduct construction projects.

VSL engineers have a cultural and professional responsibility to design safe, economical and buildable structures that meet the current and future needs of their owners and the public. VSL’s sustainable designs aim to reduce the amount of waste material, minimise the social impact of congestion caused by construction and cost less per year of service over the life of the bridge. Given VSL’s potential involvement in such a wide range of engineering works related to bridges and viaducts, it is important to contribute to environmental protection and to look for savings and recycling opportunities. This issue has become an integral part of VSL Technical Centres’ day-to-day activities.
Post-tensioning is a method of reinforcing (strengthening) concrete with high-strength steel strands or bars, typically referred to as tendons.

Post-tensioning is applied to large structures including bridges as well as others such as offices and apartment buildings, parking structures, slabs, sports stadiums, rock and soil anchors and water tanks. In many cases, post-tensioning pushes the limits of conventional construction and allows schemes that would otherwise be impossible because of either site constraints or architectural requirements.

The use of post-tensioning enables better use of materials by making the concrete work mainly under compression and the steel under tension. The result is that materials are used where they are strongest and most efficient, thus reducing the volume of materials required to build a structure.

Structures are less vulnerable to corrosion as there are substantially less – or no – cracks, because the concrete in post-tensioned structures is generally compressed.

In addition, the environment provided by the concrete gives the reinforcing steel natural protection against corrosion and so structures require less maintenance and are more durable.

The use of the VSL PT-PLUS® system with corrugated plastic ducts is recommended for applications requiring enhanced corrosion protection and improved fatigue resistance of the tendons.

Please refer to the “VSL Post-tensioning solutions” brochure for further information.

VSL Stay cables

Cable-stayed structures are ideal for spans longer than typically seen in cantilever bridges and shorter than those requiring a suspension bridge. This is the range in which cantilever spans would rapidly grow heavier if they were lengthened, and in which the spans would be too short to be economical as a suspension bridge.

VSL Stay cables have a design life of 100 years even in the most aggressive environments. Elements are fully replaceable without requiring modifications to the structure. All the materials used are carefully selected and all components are detailed to meet the highest durability criteria. In addition, the modular nature of the VSL Stay Cable System helps reduce the environmental impact of maintenance operations by minimising the amount of waste generated when parts have to be replaced during the structure’s life.

Please refer to the “VSL SSI 2000 Stay Cable System” brochure for further information.
**VSL Dampers for bridges**

Modern cable-stayed structures have to accommodate increased dynamic demands on their cables. The most versatile means of controlling vibrations is to increase the structural damping ratio of the cables by installing VSL Dampers. In addition to their high efficiency, they are adaptable, of great durability and have only very low maintenance costs, achieved by reducing the number of moving parts.

VSL’s VE and Friction Dampers are based on the principle of energy dissipation, achieved respectively by the deformation of special rubber pads or by the friction between a steel plate and a special composite pad. In contrast, hydraulic dampers are mechanically more complex, subject to oil leakage and so require substantially more maintenance. Furthermore, VSL Dampers’ mitigation of vibrations reduces the risk of material fatigue in the stays and in the bridge, which in turn reduces the need for maintenance during the service life of the structure. Dampers make a vital contribution to increasing the life expectancy of the structures where they are installed.

Please refer to the “VSL Damping Systems for Stay Cables” brochure for further information.

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**VSL Heavy lifting**

The VSL Heavy lifting methods using hydraulic jacks and strand or bar tendons are part of VSL’s core business. The approach is very versatile and allows the movement of very heavy loads safely and economically.

The application of strand lifting units for lifting, lowering and the movement of heavy loads generally involves a custom-made method for every project. The resources are mostly reused and generate the minimum environmental impact. Energy consumption is low. Other important factors are safety and ease of access. VSL’s heavy lifting equipment can be placed in locations where no crane could reach. The strand lifting systems can be adapted to every kind of technical requirement and environment to move very heavy loads easily. Loads of 30,000t have been moved without any problems.

Please refer to the “VSL Heavy Lifting” brochure for further information.

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**VSL specialised bridge equipment**

Construction of each bridge is different in many ways. Each can benefit from VSL’s specialised, tailored bridge equipment to achieve a smoothly phased construction operation.

VSL also endeavours to use standardised construction equipment for customised applications, allowing a better reuse of machinery from one project to the next. Although almost every bridge project is a prototype, the erection equipment designed by VSL to suit individual applications is subsequently re-engineered for other projects. It might be used in similar ways or for very different methods – all made possible thanks to the strengths and experience of VSL’s technical centres. This allows reuse of the same equipment many times over several years, achieving substantial reductions in the amount of new temporary works required on the projects VSL is involved in.

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**VSL Repair or strengthening solutions**

A bridge may be repaired or strengthened with external post-tensioning, cable stays, concrete and steelwork treatment, expansion joints, structural bearings and seismic devices. Repairing and strengthening minimises waste and conserves natural resources, instead of destroying them by building anew. Strengthening enables VSL to extend the life of bridges and viaducts, enhancing their capacity to accommodate new loading requirements.

Please refer to the “VSL Repair, Strengthening and Preservation” brochure for further information.
C REATING S OLUTIONS T OGETHER

SYSTEMS & TECHNOLOGIES
- Post-tensioning strand systems
- Bars & post-tensioning bar systems
- Stay cable systems
- Damping systems (stays & buildings)
- Ductal® ultra-high performance concrete
- Bearings & Joints

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