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About VSL

The VSL culture

VSL is a solution network organised around locally-based subsidiaries providing modern and cost-effective construction technologies, which are developed and updated by centralised expert R&D and technical teams.

Our aim is always to offer not only the best post-tensioning solutions but also innovative construction techniques, designed to increase site safety, save time, improve durability, and reduce costs.

We are always keen to work in partnership with our clients right from conceptual stage and have our design and method engineers working closely with their estimating teams during tender stage.

Our main strength is the quality of our highly experienced, multicultural staff. Our Marketing Staff is dedicated to listen and understand our client’s needs and to prepare customised solutions for their projects. We develop new ways of continuously training our experts through e-learning, video-learning and annual workshops where we present our new products, equipment and techniques. We also stimulate knowledge-sharing through our intranet which contains reference material, management tools and a dedicated forum where ideas about best practices are exchanged.

Our ultimate goal is to deliver the best quality service to our clients, with top quality construction techniques, backed by our experience and well-trained specialists in design, methods and job site construction.

Subscribing to the philosophy that what is good today may always be made better for tomorrow, VSL has always attracted the most talented and motivated people, all with one goal: to be your most valued construction partner.

La Unidad Bridge – Mexico

Nina Tower – Hong Kong

Shenzhen Western Corridor – Hong Kong

Sydney Airport – Australia

Lai Chi Kok – Hong Kong

Shatin T3 – Hong Kong

R&D on CS 2000 system
The company

Since 1956

VSL’s special construction systems have been used throughout the world since 1956. They are technically proven and have earned a well-deserved reputation for their quality and reliability. This has led to VSL becoming a recognised leader in the field of special construction systems/methods and related engineering.

Post-tensioning as core business

VSL technology is based on the principle of post-tensioning where the prestress is permanently introduced into the structure after the concrete has hardened. This is achieved by the stressing of suitably arranged, high-strength prestressing tendons. VSL post-tensioning generates favourable stress conditions in the structure, enabling efficient use of building materials while controlling deformations under service conditions. Complying with national and international standards, they are approved in every country where the use of post-tensioning requires official certification.

Stay cables, external cables, ground anchors, heavy lifting

The post-tensioning principle is also applicable to stay cables, external cables, structural strengthening and repair as well as ground anchors using strand or bar systems.

VSL’s understanding of post-tensioning has also led to the development of the VSL heavy lifting system which provides safe and cost-saving solutions for lifting, lowering and horizontal jacking of large and heavy loads and many other applications.

Every area of concrete construction

Multistrand and monostrand systems are used in virtually every area of concrete construction. While used primarily in bridges and buildings, VSL’s special construction systems are also employed for the construction of concrete containment structures, anchoring in rock and soil, lifting and sliding of heavy loads.

Solution finders

With offices throughout the world, VSL offers a comprehensive range of professional services for any project. These locally based services include feasibility studies, preliminary designs, alternative proposals, structural design assistance, contractor consulting and field installation, all aimed at finding the best solution and insuring the best value for money. Our locally based offices allow VSL to be close to our clients and offer our construction solutions effectively.

VSL network

VSL operates as a transnational group of companies. Its subsidiaries and licensees are organised into closely co-operating regional units. VSL customers directly benefit from the continuing development of VSL's special construction methods and from the exchange of information taking place within the VSL Network. This means that customers have local access to all the resources and expertise provided by the VSL Group. The scope of VSL's value-added services is tailored to suit client needs. VSL Companies are able to execute all works using VSL personnel and equipment. This involvement includes appropriate technical consultancy and support during planning and construction phases.
Quality, Safety and Environment

VSL to be the preferred solution network
To assist in achieving this objective the VSL group has been pursuing a dynamic, strong, coherent and decentralised QSE (Quality, Safety, Environment) policy for several years. It has established a committee whose focus is to ensure coordination of actions, encourage sharing of experience and promote best practice. As a technical leader in the post-tensioning industry, VSL works continuously, through its quality assurance program, to refine, improve, and expand the scope of its systems and services. Local QSE teams are required to have an active and effective management system that monitors and continuously improves performance.

Commitment to continuous quality
The management of VSL is committed to continuous quality improvement through the participation of all employees in the preparation, implementation and evaluation of improvement activities.

It is recognised that all our employees are vitally important to our competitiveness and prosperity and with this in mind, we aspire to maintain the highest level of satisfaction, health and safety of our people.

The VSL Group continually strives for “zero accidents” and ensures that their responsibility not only extends to their direct employees but also to workers employed by Subcontractors or in any way related to the site and its immediate environment.

This publication represents a summary of VSL's special construction systems and includes essential design and construction information for Post-Tensioning projects. Technical data and dimensions of anchorages, cables and equipment are given in the annexes. The dimensions and strengths indicated are subject to change as VSL continuously improves its systems. Additional tendon sizes are available upon request. Alternate dimensions, special conditions and various strengths may all be accommodated. Your local VSL Representative will furnish additional details regarding specific applications.

Services for fully customised solutions
These services aim to provide fully customised solutions adapted to customer requirements. VSL offers customers the strength and flexibility of a world-wide network. VSL's goal is to be a privileged partner and to help find the best-adapted solutions to particular needs.
Multistrand post-tensioning

Main characteristics

The VSL multistrand system is characterised by the following features:
- Standardized tendon units using up to fifty-five 13 mm (0.5”) or 15 mm (0.6”) diameter strands;
- Wide selection of anchorage types;
- Steel or plastic PT-PLUS® ducts;
- VSL HPIR grout or other types of grouting;
- Tendons manufactured on-site or in the factory;
- No need to determine tendon length in advance;
- Simultaneous stressing of all strands in a tendon, with individual locking of each strand at the anchorage point;
- Stressing carried out in any number of phases;
- Simple and reliable equipment for installation, stressing and grouting.

System description

Technical data and dimensions are given in the annexes. For reasons of clarity and simplicity, anchorage reinforcement are not shown in the pictures. Primary bursting and secondary equilibrium reinforcement form an integral part of the anchorage and are required to control local zone stresses. For more detailed information on the anchorage zone design, see VSL’s Report Series on “Detailing for post-tensioning”. 
Live anchorages

Type CS 2000
This revolutionary anchorage has a composite bearing plate (metal - high performance concrete) and is lighter, smaller and easier to handle. It comes in 3 different configurations: CS 2000 - STANDARD for normal applications, CS 2000 - PLUS using VSL's PT-PLUS® duct system for enhanced corrosion protection or improved fatigue resistance, and CS 2000 - SUPER able to provide an electrically isolated tendon.

Type Sc
This is a compact and easy to handle anchorage system. If necessary, the spiral can be replaced by suitably laid out orthogonal reinforcements.

Type Stronghold
This compact and easy to handle anchorage system allows prestressing force to be transferred through two flanges. If necessary, the spiral can be replaced by suitably laid out orthogonal reinforcements.
**Couplers and intermediate anchorages**

**Coupler Type KC**
This fixed coupler is used for connections to a cable that has already been installed and stressed. The strands are anchored using compression fittings positioned onto the coupling head grooves.

**Intermediate anchorage Type Z and ZU**
Intermediate anchorages are used for those tendons where the ends cannot be fitted using normal stressing anchorages.
The anchorage head is loosely placed in the blockout and moves during the stressing operation on the tendon axis.

- For pressure shaft and pressure tunnel ring tendons, avoiding the use of internal buttresses;
- For silo and reservoir circular structure ring tendons, avoiding the use of external buttresses;
- For frame, arch, foundation rafts and shell structure tension ties where there is no or limited access to end anchorages.

The VSL type ZU intermediate anchorage has similar application possibilities as type Z. It is particularly adapted to small cable units in structures without dynamic loading.

**Coupler Type Stronghold**
This fixed coupler is used for connections to a cable that has already been installed and stressed. The strands are anchored using compression fittings positioned onto the coupling head grooves.

**Coupler Type V**
This movable coupler is used for connecting to a cable that has already been installed but not stressed. The strands of the new cable are anchored using compression fittings positioned onto the coupling head of the previously installed cable.
Dead-end anchorages

VSL Type P
This type of anchorage is used where the prestressing force has to be transferred to the structure at the far end of the tendon. It consists of a plate incorporating holes for the strands to pass through. The strands are anchored using compression fittings bearing onto the plate. The compression fittings are locked into position by a retainer plate. Where the force shall only be transferred to the concrete using a bearing plate, polyethylene tubes can be used to sheath the strands between the end of the duct and the bearing plate.

VSL Type H
This type of anchorage is the best solution when strands need to be pushed through on site. The prestressing force is transferred to the concrete partially by bond and partially by end bearing (bulb). The spiral (for 5-7 / 6-7 and larger units) and tension ring prevent inadmissible stresses due to deviation forces acting on the concrete. The rebar net at the anchorage end zone acts as a spacer for individual strands.

VSL Type AF
This type of anchorage is used for vertical tendons installed once a structure is concreted, where the prestressing force has to be transferred to the structure at the lowest end of the tendon and when there is no access to the dead-end anchorage. The strands are placed in the tendons with compression fittings at their lower ends, which are then bonded into the AF anchorage with a special cement AF grout. Once the AF rout anchorage has achieved sufficient strength the tendon can be stressed from the live anchorage and then grouted.

VSL Type L
This type of anchorage is used for tendons installed once a structure is concreted and where there is no access to the dead-end anchorage. It is often used for vertical tendons in reservoir walls, for nailing pier head segments to piers in segmental bridge construction, or for horizontal tendons in slabs or foundation rafts. The strands are installed into the duct after concreting and simultaneously stressed using jacks at both stressing anchorage ends.

VSL Type LD
When loops with a smaller radius are required, special half round ducts are available upon request. VSL type LD Loops are available with a 590mm radius. The tendon sizes available are the same as type L, the difference is the duct configuration as indicated. A tight radius is good for nailing of precast segments to piers.

For dimensions of dead-end anchorages see annexes.

Anchorage components are not available in all countries. Please check with your local VSL office for availability.
Sheathing and corrosion protection

For conventional applications, corrugated steel ducts with a minimum wall thickness of 0.25mm are used, however, the VSL PT-PLUS® system with its corrugated plastic duct and plastic coupler can provide a number of important advantages when compared with conventional steel ducts. For applications requiring enhanced corrosion protection and improved fatigue resistance of the tendons, use of the VSL PT-PLUS® System with corrugated plastic duct is recommended. This fully encapsulated, watertight system offers superb corrosion protection, and the plastic duct eliminates fretting fatigue between the strand and duct.

All ducts are manufactured in a variety of standard lengths and are coupled on site.

Main advantages are:
- Greatly enhanced tendon corrosion protection;
- Improved tendon fatigue resistance;
- Reduced sensitivity to stray electric currents;
- Reduced duct friction coefficient;
- The PT-PLUS® system, when used with VSL anchorages, can be adapted to provide electrically isolated tendons (EIT). These tendons may be electrically monitored at any time throughout the life of the structure.

The PT-PLUS® system is suitable for all applications but, given its specific characteristics, is best adapted to:
- Transverse tendons in bridge deck slabs and wherever tendons are close to the concrete surface;
- Railway bridges and other structures with high fatigue loadings or subject to stray electric currents;
- Structures where severe corrosive environment may be expected;
- Tendons that need to be electrically monitored throughout the structure’s service life.

For diameters of ducts see annexes.
Selected design considerations

Spacing and cover of ducts
When determining minimum spacing and concrete cover requirements, reference should be made to applicable standards and recommendations.

Tendon supports
Recommended spacing:
Standard steel ducts 0.8 to 1.2m
PT-PLUS® ducts 0.6 to 1.0m

Tendon force losses
The effective prestressing force at a specific place and time differs from the initial prestressing force. There are several reasons for this. Significant factors include:
• Friction losses due to the curvature of the tendon;
• Concrete shrinkage and creep;
• Relaxation of the prestressing steel;
• Draw-in of the wedges during lock-off.

Friction losses along the tendon can be determined using the following formula:
\[ P_x = P_o e^{-(\mu \alpha + k x)} \]
in which:
\[ \mu = \text{friction coefficient}; \]
\[ \alpha = \text{sum of all angular deviations (in radians) over the distance } x; \]
\[ k = \text{wobble friction coefficient due to minor unintentional tendon curvatures (installation tolerances)}. \]

The \( \mu \) and \( k \) friction coefficients can vary fairly widely and depend upon several factors, including: the nature and surface condition of the prestressing steel; the type, diameter and surface condition of the duct; and the installation method.

The following values may be assumed for design:
• Tendon in standard steel ducts:
  \[ \mu = 0.2 \text{ (range: 0.16 to 0.22)} \]
  \[ k = 0.001 \text{ (range: 0.0008 to 0.0012)} \]
• Tendon in PT-PLUS® plastic ducts:
  \[ \mu = 0.14 \text{ (range: 0.12 to 0.15)} \]

Edge distances

To calculate losses due to concrete shrinkage and creep, reference should be made to the technical documents and standards applicable to each project.

The relaxation of the prestressing steel depends primarily on the type of steel (relaxation class), the extent of the prestressing, and the temperature.

For the low relaxation strands commonly used today, maximum loss is 2.5% after 1,000 hours at 20°C with an initial stressing at 70% of the nominal tensile strength. Further information can be found in the relevant prestressing steel standards and manufacturers’ literature.

Independent of the jack or tendon type, a loss of approximately 6mm due to wedge draw-in occurs at lock-off. If necessary, compensation can be provided by appropriate procedures.
**Multistrand post-tensioning**

**Stressing**

The unique feature of the VSL post-tensioning system lies in its special wedge locking procedure. The wedges always remain in contact with the strands during the stressing operation. As the pressure in the jack is released, the wedges automatically lock in the conical holes of the anchor head.

**Grouting**

The objectives in grouting a tendon are two fold:
1. To provide an effective corrosion protection system, by filling the free space in the tendon with the grout which provides an alkaline encapsulation of the tendon, and
2. To achieve an effective bond between the tendon and the surrounding concrete.

It is therefore essential that grouting be carried out in a carefully monitored and controlled manner. Through extensive R&D VSL has developed a detailed understanding of both the chemical and practical aspects that affect grout quality and has produced specific grouting procedures and grout mixes which are tailored to suit local conditions and material properties – VSL’s HPI® high performance cimentitions grouts. VSL uses combined mixer and pump units to ensure control over the grout quality and delivery on-site and can also provide vacuum assisted grouting procedures for certain special applications such as long cables, external tendons or electrically isolated tendons.

For dimensions of the jacks, please see annexes.

For more information on VSL HPI® grouting, please refer to the VSL HPI® grouting brochure.
Construction sequence

Today’s building owners and designers need to provide a high level of structural flexibility to meet changing user requirements.

Post-tensioning provides greater spans with reduced structural floor depths, resulting in larger column-free areas. As a result, internal layouts are not dictated by tight column grids. Positive deflection and crack control and, if necessary, joint-free water-tight slabs, free designers from the limitations of traditional reinforced concrete structures. VSL post-tensioning is more economical than other systems, especially when fast construction cycles are envisaged. There is less material handling on site and a reduced labor force, minimizing site congestion. Most importantly, there is the quality and service provided by VSL’s specialized highly efficient teams.

The VSL bonded post-tensioning slab system has been used in many prestigious buildings, bridges and other structures. The system uses up to five strands 13mm (0.5”) or 15mm (0.6”) contained in flat-shaped ducting, and anchored in a single anchorage.

Strands are individually stressed and gripped by wedge action. After stressing, the duct is filled with a cement grout that fully bonds the strands to the surrounding concrete.
Bonded slab post-tensioning

Live anchorages

VSL Type SO

Grout tube
Recess former
Strands
Wedges
Anchor body
Trumpet
Flat duct

VSL Type S

Grout tube
Wedges
Strands
Casting
Anchor block
Recess former
Duct

VSL Type Bondtech

Grout tube
Wedges
Strands
Anchorage
Recess former

VSL Type S5 – 2

Grout tube
Duct
Cast in anchorage
Barrels & Wedges grips
Wedges
Strands

VSL Type S5 – 1, S6 – 1

Grout tube
Duct
Cast in anchorage
Wedges
Plastic
Strands
Recess former

For dimensions of anchorages see annexes.

Anchorage components are not available in all countries. Please check with your local VSL office for availability.
**Couplers**

**VSL Type SK**
- Grout tube
- Compression fittings
- Coupling head SK
- Sleeve
- Flat duct
- Trumpet
- Steel band
- Strands

**VSL Type S**
- Grout tube
- Compression fittings
- Grout tube
- Duct
- Cast in anchor
- Anchor head
- Cast coupling block

**Dead anchorages**

**VSL Type H**
- Grout tube
- Tension ring
- Spacer
- Bulb
- Flat duct
- Seal

**VSL Type N**
- Grout tube
- Tension ring
- Individual anchorages

**VSL Type P**
- Grout tube
- Tension ring
- P-plate
- Compression fittings
- Flat duct

For dimensions of couplers and dead anchorages see annexes.

Anchor components are not available in all countries. Please check with your local VSL office for availability.
**Selected design considerations**

- Spacing of tendon supports:
  - 0.75 to 1.2m (steel ducts)
  - 0.75 to 1.0m (PT-PLUS® ducts)
- Minimum curvature radius:
  - 2.5m (vertical profile)
  - 6.0m (horizontal profile)
- Min. straight length at anchorage:
  - 0.75m
- A wedge draw-in of approximately 6mm occurs at lock-off
- Friction losses can vary fairly widely depending on factors such as surface condition of strands, duct types and surface condition, material properties, installation methods and on-site workmanship. Generally speaking, the following friction parameters can be used.
  - Tendons in standard steel ducts:
    - \( \mu = 0.20 \) (-) (range: 0.16 to 0.22)
    - \( k = 0.001 \) (m-1) (range: 0.0008 to 0.0012)
  - Tendons in PT-PLUS® ducts:
    - \( \mu = 0.14 \) (-) (range: 0.12 to 0.15)
    - \( k = 0.001 \) (m-1) (range: 0.0008 to 0.0012)

The friction losses in the anchorage due to curvature of the strand and friction of the strand in the wedges usually amount to:

- Edge stressing 3% average
- Internal pocket stressing 5% average

The PT slab method allows designers to reduce building heights or to increase free heights between floors.

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**Traditional design**

- Free height

**PT slab design**

- Height saving
- Free height
Monostrand unbonded post-tensioning

System description

The VSL monostrand unbonded system has advantages similar to those of the VSL bonded slab post-tensioning system.

The VSL monostrand unbonded system uses 13mm (0.5”) or 15mm (0.6”) diameter strands, which are given a coating of permanent corrosion-preventing grease and are enclosed in an extruded plastic sheathing.

The grease and plastic provide double corrosion protection, as well as preventing any bonding between the strands and the surrounding concrete. The plastic sheathing is usually in polyethylene or polypropylene with approximately 1mm wall thickness. The monostrands are installed either singly or in bundles of two, three or four. Each strand is individually anchored, stressed and locked-off.

To ensure continuous corrosion protection, special sleeves are used to join the sheathings to the anchorages. Anchorages can be equipped with a protective cap.

Monostrands feature factory-applied corrosion protection, very low friction losses, and permit the structural depth to be fully utilised.

These light, flexible monostrands can be easily and rapidly installed, and because there is no grouting, they usually lead to economical solutions.

In design, the different post-cracking behaviour of unbonded versus bonded systems should be considered. Detailed information is given in VSL’s “Post-tensioned slabs” publication.

With certain adaptations, the VSL monostrand unbonded system can also be used for post-tensioning masonry walls.

Tendon characteristics

- 13mm/15mm diameter strand in accordance with the relevant prestressing steel standards.
- External diameter of the plastic sheathing: approximately 16mm and 18mm (0,5”) respectively. Permanent corrosion-preventing grease and plastic sheathing in accordance with fib/PTI recommendations (0,6”).
Anchorages

**VSL Type S**
- Anchorage body (casting)
- Installation piece
- Recess former
- Installation nut
- Monostrand
- Wedge
- Sleeve
- Monostrand

**VSL Type SF**
- Monostrand
- Sleeve
- Cap
- Anchorage body (casting)

**VSL Type ST System**
- Monostrand
- Sleeve
- Transition cone
- Wedge
- Anchorage
- Recess former
- Strand

Couplers

**Coupler type SK**
- Monostrand 1
- Sleeve
- Wedge
- Coupling head and threaded coupling
- Sleeve
- Monostrand 2

For dimensions of anchorages, stressing jacks, reinforcement of the anchorage zone and design values see annexes.

Anchorage components are not available in all countries. Please check with your local VSL office for availability.
Characteristics

The VSL post-tensioning system is widely used in the construction of slabs on grade. Warehouses, distribution centres, container terminals, airports, pavements, residential slabs and recreational slabs for tennis courts and skating rings are common applications.

Eliminate joints

Joints in reinforced concrete slabs on grade have long been a cause of cost and delay to owners because of the constant maintenance they require. Owners and operators of facilities with slabs on grade can eliminate these costs by eliminating the joints themselves. The VSL post-tensioned concrete slab on grade is cast in very large areas, often exceeding 2 500m², in which there are no joints. In certain applications, slabs in the order of 10 000m² have been constructed without movement joints.

Crack-free performance

The VSL post-tensioning axially compresses the concrete slab to counteract tensile stresses which would otherwise cause cracking under the worst combinations of temperature and applied loads. The prestress applied can even control the initial concrete shrinkage sufficiently to prevent initial shrinkage cracking.

Thinner slab

The VSL slab is much thinner than its equivalent in reinforced concrete, and generally contains no reinforcement except at the perimeter and for trimming at penetrations.

Initial cost

The thinner slab, absence of reinforcement, absence of costly internal jointing and the cost saving available from the construction program time saved by casting large areas, all contribute to a competitive initial cost.

Future maintenance

During the life of the slab, the joint maintenance costs which the owner no longer needs to provide, will reap great improvements in the efficiency of the facility.

A life cycle analysis can be readily undertaken to demonstrate that future savings to the owner more than justify the selection of a VSL slab on grade.
External post-tensioning

System description

External post-tensioning is well adapted to bridges due to the resulting reduction of congestion inside the concrete and the high degree of corrosion resistance provided by the system. External tendons are easy to inspect and, if necessary, replace. They are ideal for strengthening existing structures and, apart from their uses in bridges, can be used for a wide range of other applications, including buildings, silos and reservoirs.

VSL external tendons comprise:
- Strand bundle;
- Polyethylene ducts;
- Standard multistrand anchorages, and special anchorages permitting complete tendon replacement;
- Grouting compound.

A wide selection of VSL anchorage types is available to meet the full range of practical requirements. In addition to the anchorages illustrated here, intermediate anchorages are also available. The strand bundle can be assembled from uncoated or individually greased and sheathed strands. The anchorages for these two types of tendon differ only in detail, the principle remains the same.
Selected design considerations

Saddles at points of deviation
A saddle at a point of deviation consists of:
• A structural element capable of carrying the loads exerted by the tendon in the deviation zone;
• A part ensuring the geometry of the deviation.

Globally a saddle at a point of deviation must satisfy the following requirements:
• Withstand both the longitudinal and transversal forces that the tendon applies to it and transmit these forces to the structure;
• Ensure, without unacceptable angular deviation, the connection between two straight tendon sections;
• Unless otherwise stipulated in the contract, enable removal of the tendon without traumatic effect on the structural elements;
• Withstand movements of external tendon during stressing without compromising the tendon’s corrosion protection system.

Various solutions have been used in practice, as shown in the sketch. In most cases, saddles consist of a pre-bent steel tube cast into the surrounding concrete or attached to a steel structure by stiffening plates. The connection between the free tendon length and the saddle must be carefully detailed in order not to damage the prestressing steel by sharp angular deviations during stressing and in service. It is also important that the protective sheath be properly joined. If tendon replacement is a design requirement, the saddle arrangement must be chosen accordingly, i.e. double sheath as shown on alternative (3) of the sketch.

Minimum tendon radii
Minimum tendon radii as recommended in Table 1 must be respected in order to avoid damage to the prestressing steel and the plastic sheaths, as well as to the outer tubing. It is well-established that friction problems may occur if tendon radii are too small.

Table 1: recommended minimum tendon radii

<table>
<thead>
<tr>
<th>Tendon size (VSL tendon unit)</th>
<th>Minimum radius (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 5-19 or 6-12</td>
<td>2.50</td>
</tr>
<tr>
<td>up to 5-31 or 6-19</td>
<td>3.00</td>
</tr>
<tr>
<td>up to 5-55 or 6-37</td>
<td>4.00</td>
</tr>
</tbody>
</table>

For dimensions see annexes.
Anchorage components are not available in all countries. Please check with your local VSL office for availability.
For more information on external post-tensioning, please refer to VSL Report N° 1.
Stay cables

SSI 2000 description

VSL stay cable system
The VSL stay cable system was developed to meet the stringent design, construction and maintenance requirements of cable-stayed bridges.

The VSL stay cable system comprises
- a tendon formed from multiple and parallel 15-mm (0.6") dia. high tensile 7-wire steel strands;
- a greased or waxed strand, with a tightly extruded plastic sheathing;
- an outer thick-walled plastic stay pipe;
- factory prefabricated anchorages.

The system features are as follows
- 200 MPa minimum fatigue resistance at 45% of tendon capacity over 2,000,000 load cycles;
- high degree of corrosion resistance using multi-layer corrosion protection;
- an extruded coating providing excellent strand corrosion protection during construction;
- individual strand encapsulation and sealing in anchorages;
- easy installation of the strands into the erected stay pipe (single strand installation);
- all strands are parallel with no risk of twisting;
- single strand stressing;
- no requirement for on-site cable grouting;
- easy tendon force monitoring and adjustment throughout the cable’s service life;
- ability to remove and replace individual strands without dismantling the installed anchorages, or the entire cable at any time;
- system adapted for the initial or future installation of anti-vibration dampers.

Characteristics

Compactness
- reduced size of the anchorage for easy installation and savings in the cost of the structure.

Aesthetics
- using coloured co-extruded stay pipes, different colours can be obtained;
- vibration damping devices can be placed at the end of the guide pipes near the deck.

Dynamic stability of the cables
- stay pipes with external helical ribs to suppress rain-wind induced vibrations;
- the stay cable system is adapted for the initial or future installation of anti-vibration dampers;
- the new generation of VSL friction or Gensui dampers dampers to offer minimum maintenance during extended design life.

Durability
A high degree of corrosion protection:
- each strand is individually protected not only in the stay pipe, but also in the transition part of the anchorage;
- individual anchorage sealing joints protect each strand not only in service, but also during bridge erection;
- VSL’s stay cable system has the unique feature of providing complete encapsulation for each individual monostrand along the free length and into the anchorage.
VSL stays with architectural bars

VSL architectural bars are particularly suitable and economical for shorter road bridges, pedestrian bridges and stays for suspended roofs.

Single strand monitoring

VSL has designed a compact load cell, the SSI 2000 Hc160, to monitor the load on a single strand within a stay cable. This new equipment fits over one strand and sits on the anchor head of the stay cable between adjacent strands, making it easy to install and replace. This load cell offers an economical way to have a good indication of the total force on the stay cable.

Increased stay anchorage protection

Deviator placed in the guide pipe provides an additional level of protection by filtering cable bending stresses before they reach the anchorage.

Versatile

Designed to receive in the future vibration damping systems (friction dampers) if necessary.

Replaceable strands

Ability to remove and to replace individual strands on demand.

Economical

Faster installation and erection cycles. Reduced maintenance.

Reduced maintenance costs

• easy corrosion control of anchorage components;
• good access to vibration damping systems.

Stay cable installation

• system optimised for strand-by-strand installation, with easily handled, lightweight equipment and reduced construction loads on the bridge during construction.

Unlike systems used by competitors which compromise the encapsulation near the anchorage point and result in potential exposure of the entire cable, VSL’s stay cable system reduces the potential exposure to a single strand.

For more information on VSL stays, please refer to the VSL Stay Cables brochure.

For more information on architectural bars, please refer to the VSL Architectural bars brochure.

Stay Free Length

Guide Deviator

With Deck Connection

STAY FREE LENGTH

GUIDE DEVIACTOR
Custom engineered solutions for tough jobs

For economic or technical reasons, today’s civil engineering structures and industrial plants are often assembled from large, heavy, prefabricated components. VSL Heavy Lifting will often provide the most effective solution for projects where cranes or other conventional handling equipment cannot be used.

Individual solutions
VSL can plan lifting, horizontal jacking, or lowering operations and design the necessary temporary structures needed to meet your requirements.

Safety
The safety of your personnel and works is VSL’s first priority. Our specialised hydraulic lifting equipment is designed to provide the highest level of reliability, and VSL field services are based on a total commitment to safety.

Flexibility
Our equipment includes a large number of hydraulic strand units, jacks, pumps, control units, monitoring devices and modular lifting/jacking frames, giving us the capacity to perform virtually any project requiring lifting, lowering or horizontal jacking.
VSL service package

Our approach is flexible, and the range of our services is tailored to the specific project requirements. They include:
- feasibility studies and preliminary consultation;
- project design and planning;
- design, manufacture, and supply of special equipment;
- leasing of VSL equipment and execution of work.

Proven equipment for handling heavy loads

VSL strand system
The main components of the VSL strand system are the motive unit, the tensile member with the anchorage for the load, and the pump with its controls.

Motive unit
The motive unit consists of a hydraulic centre hole jack with upper and lower anchorages. During lifting the jack is extended, causing the individual strands of the tensile member to be gripped by the upper anchorage and thus to be moved upwards. At the start of the pistons downward movement, the strands are immediately gripped by the lower anchorage. In this way, the load is raised using a step-by-step process.

For lowering operations, VSL’s motive units are equipped with an auxiliary device which automatically controls the opening and closing of the anchorages.

Tensile member
The tensile member consist of 15 mm (0.6”) strands. The tensile member is anchored to the load by a specially designed end anchorage.

Hydraulic pumps
VSL electro-hydraulic pumps can be manually controlled or operated in groups from a central control board.

VSL has a wide range of pumps with either single or multiple outlets. The characteristics of these pumps ensure the synchronised movement of the jacks. Pressure control devices allow forces to be monitored at all times. The movement speed varies according to the project and, if required, can be in excess of 20 m / hour.

Control and monitoring systems
The lifting of hangar roofs or of similar statically overdetermined structures usually requires that lifting movements be precisely co-ordinated. This is achieved by specially designed, computer-based multi-point monitoring systems, which allow the operation to be centrally controlled and monitored up to the final, precise height.

Special hydraulic equipment
Our range of equipment also includes a large number of different hydraulic jacks. VSL can also design and supply custom-built hydraulic systems for special applications.

For more information, please refer to the VSL Heavy Lifting brochure.
VSL experience

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 schedule, while maintaining and often improving 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) and also constructing multiple insitu bridges utilising VSL form travellers and incremental launching methods. VSL is committed to offering clients a “best for project” service that has recently led to the development and successful implementation of various innovative Partnering and Alliancing arrangements that have proved to be highly successful and mutually beneficial to all parties involved.
VSL slipform

The VSL Slipform System has been used in the construction of silos, storage tanks, containment structures, chimneys, cooling stacks and bridge piers and pylons for over 20 years. Slipforming is advantageous when rapid construction between 2 and 6 m per 24 hours is required which results from continuous working it forms a monolithic structure free from construction joints. The system is raised by hydraulic jacks with upper working platforms for reinforcement fixing and concrete placement and a suspended scaffolding for finishing works.

VSL climbform

VSL has also been active in Climbforming for over 20 years. The VSL Climbform System is a self climbing heavy duty construction platform used primarily to lift static panel vertical wall formwork. The system provides the wall designer with complete flexibility in both the structural design and selection of finishes. The system is particularly adapted to the construction of high-rise building cores. The 6-m high VSL Climbform has three platform levels, and the formwork panels hanging from the external frame and internal platforms permit pours over a height of 4.2 m. The internal steel platforms, incorporating the formpanel hooks and rollers, are specifically designed and manufactured for each project, guaranteeing accurate and economic assembly operations.

VSL Climbform permits an excellent production ratio with accurate placing of door frames, openings, blockouts, cast-in components and direct placing of prefabricated reinforcement cages. Another advantage lies in the safety of the Climbform. The VSL service package includes: feasibility studies and preliminary consultation and pricing; tender design and planning; design, manufacture and supply of equipment; leasing, training of site-staff, supervision of the works for the first few levels, followed by dismantling operation.

Standard features include:
- Custom designed formwork panels which may be ganged in any shape or size to lift as one unit
- Form heights ranging from 2.5 to 4.2 metres
- Unobstructed access to the forms for cleaning and oiling, fixing of door frames and blockouts as well as reinforcement and reinforcing fabric fixing, including prefabricated reinforcement
- Truss members of fixed height assembled in “Meccano like fashion” to form a platform of any plan shape or size
- Easy levelling and plumbing of the external platform, which is typically supported on four, six or eight seatings
- Minimum adjustment of individual forms after the initial set-up
- An achievable vertical tolerance range of 10mm per 4.2 metre height
- Variation of wall thickness by moving the internal or external forms
- Parking the internal platforms at mid-lift to facilitate blockout and reinforcing fixing, eliminating the requirement for temporary scaffolds
- Cycle times as low as three days
- Access to external walls for curing
- Hanging access stairway.

Optional features include:
- Steel formwork to enable pouring within 50mm of boundaries
- Support of concrete placing booms on the platform
- Access hatches and/or temporary removal of platforms to install precast stairs
• external trailing platforms
• internal trailing platforms to allow early installation
• support of site sheds and toilets on the platform
• provision to allow manhoists to service the top working platform
• provision to locate tower cranes within internal and corridor platforms
• collapsible door formers
• trailing formwork and platforms for vertical and raking walls.

VSL form travellers

VSL Form travellers have been developed in conjunction with the in-house design of balanced or free cantilevering bridge structures. The form traveller of either overhead truss or underslung type, is a hydraulically driven falsework system with built-in working platforms and formwork panels designed to provide a rigid frame to minimize deflections under load.

System flexibility

The VSL Form traveller system is designed for a variety of segment lengths varying from 3m to 5.5m and can support concrete and formwork loading from 100t to 450t. The traveller system design can accommodate wide variations in segment length, height, web thickness and deck width and geometry. Vertical deflections at the leading edge of the traveller assembly are less than 25mm at maximum loads.

System operation

The VSL Form traveller system is economical and efficient to use. Launching is accomplished by advancing the system forward on rails. The interior formwork remains within the previously poured section in order to facilitate the placing of the reinforcing steel in the bottom slab and webs of the new segment. The segment construction cycle can generally be carried out in less than a week. A typical segment cycle would consist of the following steps:

1. The system is launched on rails to the new segment location.
2. The external formwork is aligned, levelled and fixed into place.
3. Reinforcing steel is placed in the bottom slab and web walls.
4. The interior formwork assembly is advanced, and the top deck slab soffit and wall forms are levelled and fixed into place.
5. Reinforcing steel and post-tensioning tendons are placed in the deck slab.
7. Stressing of post-tensioning tendons.
8. The internal and external formwork is stripped from the cast and cured segment and the VSL Form traveller is launched to the next segment.

VSL services

VSL provides design, fabrication, material supply and installation services to the balanced cantilever construction process. Our engineering team supports the custom design of the Traveller System to meet the needs of a specific project and bridge configuration. Complete system drawings and operation manuals detail all aspects of traveller operation for ease of assembly and safe operation. VSL is ready to provide technical assistance and field supervision of traveller 1st assembly and commissioning, launching, maintenance and dismantling or a total turnkey package incorporating the operation of the system with the post-tensioning application.

For more information, please refer to the VSL Bridge Erection brochure.
Upgrading deficient -but in service structures is a challenging and growing segment of the construction industry. VSL strengthening systems are providing economical solutions for structures requiring load capacity upgrade or improvement due to change of use, deterioration or construction defects.

Structural appraisal and diagnosis
Structural remedial work demands thorough diagnosis of damage/deterioration and full assessment of causes, risks and consequences involved.

VSL employs state-of-the-art equipment and special inspection techniques to detect any defects in concrete, reinforced concrete, and prestressed concrete structures before any significant damage occurs. Close cooperation with material testing institutes, structural designers and the latest investigation techniques enable VSL to prepare precise and comprehensive reports such as:

- Inspection and surveyance of concrete structures
• Condition evaluation of concrete structures
• Root cause analysis
• Design of repair strategies
• Budget costing.

To repair or not to repair......
Once the external signs of a structural problem have been observed, the next step is critical: to identify the underlying cause.

Any decision to repair – and the repair strategy- should never be based solely on effect. It should always arise from an analysis of the cause.

A solid understanding of the root cause will help determine whether the observed effect actually warrants a repair.

Many owner-related issues must also be assessed - safety, environmental effects, change of structural usage, new design loads, and risk level, to name just some – before a wise decision can be made to repair or not to repair.

Tailor-made systems
VSL is a one-source solution for structural upgrades or repairs. Our systematic approach to the analysis, load test design and execution of strengthening projects allow us to integrate our engineering, manufacturing and installation capabilities into a creative, efficient, timely and cost-effective approach.

A challenging aspect to this process is that deficient structures are in service and functioning, therefore, the repair or strengthening systems must be tailored to serve the intended use of the structure without interfering with its occupants or function.

As a result of the higher load demands, existing structures need to be reassessed and may require strengthening to meet heavier service loads. In general, structural strengthening may become necessary due to code changes, seismic upgrade deficiencies that develop due to environmental effects such as corrosion, changes in use that increase service loads, or deficiencies within the structure caused by errors in design or construction.

A combination of techniques
The structural upgrade of concrete structures can be achieved using one of many different upgrading methods such as external or internal post-tensioning systems, span shortening, externally bonded steel, fiber reinforced polymer composites (FRP), section enlargement, or a combination of these techniques. Strengthening systems must perform in a composite manner with the existing structure in order to be effective and share the applied loads.

For more information, please refer to the VSL Repair and Strengthening Brochure.
VSL has been manufacturing and designing bars for the construction industry since 1971. VSL has an extensive list of hot-rolled products as well as cold-rolled bars. These have proven to be one of the most popular tools of engineers wishing to induce and control loads and forces in structures.

VSL’s product line complies with international standards, including ISO, Eurocodes, ASTM, Australian Standards, British Standards, and such like.

A range of diameters is available to give a wide selection of tendon forces. The prestressing force is anchored at the end of the bar by a rolled thread, nut, washer and bearing plate. Where necessary bars can be joined with threaded couplers, and clevis fittings may be used where pin connections are required.

VSL Bars systems are specifically designed to suit all geotechnical applications as well as civil works and building applications. The systems range from High Tensile Cold Worked Stressbar to Low Tensile Architectural bars, all with compact and easy to assemble fittings.

VSL bar systems are ideal for the economic application of post-tensioning forces on relatively short tendons. Through the use of threaded connections and anchorages they are simple to use and lend themselves to many applications.

All bars and fittings must receive protection when installed under permanent conditions or used in an exposed environment. One of the following coating systems may be used.

- Galvanising
- Greased and sheathed in a polyethylene tube
- Epoxy paint system

A combination of the above systems may also be specified. Consideration must also be given to the threaded ends to ensure correct installation of fittings after coating.

**Typical applications**

**Buildings**
- Prestressed beams and columns
- Precast connections

**Bridges**
- Stay cable
- Hangers
- Temporary prestressing of segments
- Strengthening
- Tension piles and caissons

**Wharves & jetties**
- Stressed deck planks
- Tie backs

**Anchors**
- Permanent and temporary ground anchors
- Uplift anchors (dam & foundation)
- Roof bolting
- Soil nails (slope stabilisation)
- Crane bases
- Light towers

**Specialist Engineering**
- Heavy lifting
- Formwork ties or hangers
- Frame ties
- Pile testing
- Architectural ties
**Rock bolts**
- Stabilising galleries during excavations
- Stabilising unstable rock/soil
- Flexible attachment thanks to the high level of steel elongation/ductility
- A range of different anchoring systems
- Grouted, resin anchors, expansion shells
- A large number of special accessories

**Soil nails**
- Slope stabilisation
- Retaining wall strengthening
- Flexible attachment thanks to the high level of steel elongation/ductility, permitting soil movement
- Permanent and temporary use

**Micropiles**
- Foundations (compressive load)
- Tensile piles (tensile load)
- Ideal for alternating tensile and compressive loadings
- Securing of building foundation walls, embankments, compacted soil areas, high-rise buildings, structures in seismic areas

**Ground anchors**
- Tie-backs
- Retaining walls
- Stabilising deep excavations, anchoring tower cranes
- Permanent and temporary use

**Tie rods**
- Tie-backs
- Retaining walls
- Sea walls
- Permanent and temporary use

**Reinforcements**
- DIN 488 accreditation for B500 steel quality
- Convenient for coupling through the use of continuous threading
- Efficient coupling solution in areas where there are too many steel components
- Alternative to shear studs

**Stress bars**
- High performance for forces ranging from 270 to 1,320 kN
- Prestressed/post-tensioned concrete structures
- Strengthening of buildings
- Temporary prestressing and bracing

**Form ties**
- Same production quality level as high grade stress bars
- Additional steel qualities, e.g. St 1,000/1,100 (weldable, high ductility, suitable for low temperatures), S850/900 steel with cold-rolled thread
- Accessories to suit all assembly situations

**Architectural stress bars**
- Foot bridges
- Small road bridges
- Suspended roofs
- Curtain walls
VSL Anchors can be divided into two main categories — strand and bar anchors. The type of anchors used depends on whether it is for rock or soil, for temporary or permanent use, whether or not it is to be tensioned, and whether or not permanent corrosion protection is required.

VSL offers all of these alternatives can support a full anchor material supply service (anchors and accessories) with back-up including design services, advice, consultancy, testing, installation, tensioning, site supervision and monitoring. The construction of the VSL strand anchor depends on the type of application (rock or soil), the design, the corrosiveness of the environment, the presence of stray electrical currents and the intended service life. While temporary ground anchors require limited or no corrosion protection, permanent ground anchors (with a service life exceeding two or three years) need to provide a comprehensive permanent corrosion protection system.

Specific requirements
Anchorages can be designed to allow the anchor force to be adjustable, releasable or be used as a monitoring anchor. VSL’s range of anchors extends from permanent anchors that allow electrical resistance measurements to be taken to check the integrity of the encapsulation during the entire service life, to temporary anchors that can be easily extracted after use. VSL also offers load cells that allow the anchor performance to be monitored. The anchor shown on this page represents a typical permanent strand anchor with a thick walled polyethylene encapsulation acting as a protective barrier against corrosion. Temporary anchors are similarly constructed except that, being designed for a shorter service life, corrosion protection requirements are usually less demanding. The anchor is not normally encapsulated and can take the form of a bundle of bare strands in contact with grout over the bond length of the anchor.

Both types of anchor systems comprise the anchor with a bearing plate, anchor head and wedges.

Electrically isolated anchors
These anchors use tight PE encapsulation combined with an electrically non-conductive anchorage isolation. The integrity of the anchor can be checked throughout its service life using electrical resistance measurements.

Force measurements
VSL is able to provide specially developed load cells for temporary and permanent control anchors, as well as for permanent surveillance anchors. The following three types are available:
- type G hydraulic load cell, permanently installed for control anchors;
- type GW hydraulic load cell, used as a removable load cell allowing several permanent anchors to be measured from time to time by moving the cell from one anchor head to the other;
- type D electrical load cell, providing supervision of permanent and temporary anchors and allowing continuous load measuring using either a direct or remote reading system.

All load cell types are fully compatible with the VSL Anchor system. Our scope of services includes consultancy, supply and installation of load cells, as well as control anchor readings.
**Anchor load checks**

VSL performs periodic anchor load checks using suitable equipment and competent personnel. This is carried out by lift-off checks using VSL jacks or the required type GW load cells. Standard load checks can be carried out on type EG, ER and EA anchorages. With our specially developed APP jacks, we are in the unique position to carry out lift-off checks on anchors with type EF anchorages where the anchor head has no thread and where projecting strands were cut after installation. The jack has a mechanism to grip standard size anchor heads with up to twelve 13 mm (0.5") strands or seven 15 mm (0.6") strands. This allows clients to carry out load checks in situations that, in the past, had been particularly difficult.

**Anchor extraction**

It is often undesirable to leave temporary anchors in the ground, particularly in urban areas where they normally extend into adjacent property. The method developed by VSL for extracting the free anchor length is based on a specially designed mechanism located at the point where the strand is disconnected. VSL has a long tradition in this special technique, with thousands of anchors successfully extracted. VSL offers also temporary stressbar anchors which permit partial extraction.
The VSoL® retained earth system is a composite soil reinforcing system that uses welded wire mesh or polymeric strips to resist the horizontal forces generated within an earth backfill. A retained earth structure is a stable, unified gravity mass that can be designed for use in a wide range of civil engineering applications. The VSoL® system is widely used and accepted as a major construction method in projects ranging from retaining walls to highway bridge abutments. The basic retained earth principle involves transferring stresses from the soil to the reinforcing elements. In the case of welded wire mesh soil reinforcement, this is achieved by the development of passive resistance on the projected area of the mesh crossbars, which in turn transfers load into the longitudinal bars. In the case of polymeric strip reinforcement, load transfer from the backfill is achieved by the frictional interaction of the soil particles with the polymeric reinforcing strip. In addition to its high performance level, the VSoL® system ensures economical design and construction. The system requires only three components: reinforcing elements, precast facing panels and backfill material. This simplicity results in easy and rapid construction. Cost savings of up to 50% below those of traditional retaining wall systems are regularly achieved.

**Fast, easy and economical**
The construction of a VSoL® structure is particularly straightforward.
A five-man crew using standard construction equipment can place an average of 75 m² - and as much as 140 m² - of wall per shift.

**Complete services**

VSL advises customers and their consulting engineers during the feasibility stages of projects, and prepares preliminary design and cost estimates, as well as detailed designs, drawings and specifications. The company also assists contractors with the pricing of tenders, and provides quotations during tender stages. Execution of the on-site project can be tailored to suit the customers’ requirements, from a supply only arrangement to a full sub-contract agreement.

**Complete flexibility**

VSoL® system concrete facing panels are available in a wide range of shapes, textures and colours. Because local materials are used in the production of these precast panels, the visible exposed surface can easily be coloured to match the natural surroundings. Raised relief, sandblasted finish, exposed aggregate, and conventional smooth face concrete represent just a few of the available standard retained earth panel finishes. Other facing systems, such as modular blocks, and mesh are also available for both permanent and temporary structures.

For more information, please refer to the VSoL® Brochure
Ductal® is a material with a unique combination of superior characteristics.

The material was developed by Bouygues in partnership with Lafarge and Rhodia under the generic name of Reactive Powder Concrete and is marketed under the brand name of Ductal®. Composed of fine particles with a maximum size less than 0.8mm, Ductal reaches compressive strengths of 170 to 230 MPa.

In structural applications, Ductal® is used without any passive reinforcing bars. Very fine, high strength steel fibres are provided to withstand secondary tensile stresses due to shear, tension, small bending moments and concentrated loads. Pre-or post-tensioning counterbalances the main tensile stresses due to large bending moments. The steel fibres also provide significant ductility to the cementitious paste.

In non-structural applications, Ductal® is used with non-metallic fibres. Passive steel reinforcement and prestressing are not required. Ductal® has the ability to replicate the micro and nano-texture of the mould. When combined with the fluidity and the ability to have a range of colours, the result is a material that provides a high quality surface appearance together with high strength and durability.

The durability properties are those of an impermeable material. There is almost no risk of carbonation or...
penetration of chlorides and sulfides, and the resistance to acids is improved.

**Main advantages**
- Eliminates completely the need for conventional reinforcement
- Greatly improves durability, with a resistance to permeability 50 times better than normal high strength concrete
- Permits the use of much thinner sections
- Provides complete freedom on the shape of the section
- Reduces the concrete volume of a structural member to only one third to one half of its conventional volume
- Dramatically reduces the structural weight to be supported by a structure
- Provides both direct and indirect cost savings.

**Strength characteristics (steel fiber reinforced)**
- Compressive strength (cylinder) .................. 170-230 MPa
- Flexural strength (3 point bending test) .................. 40-50 MPa
- Youngs modulus (E) .................................. 50-60 GPa
- Total fracture energy .................................. 20,000-30,000 J/m²

**Rheology**
- Fluid to self compacting
- Flow (Abrams cone) .................................. 50-70 cm
- Flow (ASTM shock table) .......................... 250 mm

**Durability**
- Chloride ion diffusion (Cl⁻) .................. 10-12 m²/s
- Carbonation penetration depth .................. <0.5 mm
- Freeze/thaw (after 300 cycles) .......... 100%
- Salt-scaling (loss of residue) .......... <10 g/m
- Abrasion (relative volume loss index) .................................. 1.2

**Other properties**
- Density .................................. 2450-2550 kg/m³
- Entrapped air content .................. 2-4%
- Freeze/thaw (after 300 cycles) .......... 100%
- Total porosity .................. 2-6%
- Shrinkage after heat treatment .......... 0
- Creep coefficient .......................... 0.2-0.5

**Typical applications**

**Bridges**
- Beams
- Truss type structures
- Decks of steel bridges

**Buildings**
- Beams
- Slabs
- Permanent floor formwork
- Curtain wall panels
- Facade panels
- Columns
- False floor panels
- Grandstand seating plats

**Railways**
- Sleepers
- Sound absorbing panels
- Noise walls

**Highways**
- Light poles
- Crash barriers
- Noise walls

**Civil**
- Pipes
- Hazardous waste containment
- Arch culverts

**Other**
- Blast protection
- Vaults

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*Reina Sofia – Spain*

*Ductal® blast – Australia*
Generally, structural bearings are required to connect different parts of a given structure, such as a bridge deck to piers and abutments. The most widely used structural bearings are reinforced elastomeric bearings and pot bearings. They are capable of transmitting forces while absorbing the structure's deformations and rotations. The strength of reinforced elastomeric bearings is limited by the shear properties of the elastomeric block, especially when compression, shear and bending occur at the same time. Pot bearings maximise the shear strength of the bearings elastomer by encasing it in a steel cylinder. Elastomeric and Pot bearings can be fixed, guided or free depending on design requirements.

VSL offers fixed pot-bearings which permit movement in one or any direction. Pot bearings for incrementally launched bridges have a dual function. First, they provide low friction sliding surfaces over piers as the deck is pushed during construction. Thereafter, they become permanent bearings. A pot bearing serving these functions is shown in the picture above. During construction, a fixing device avoids relative movement between the sliding plate and the pot cylinder.

The sliding plate is equipped with an upper stainless steel panel. This is followed by the insertion of neoprene-teflon pads during the launching operation to be carried out. The pads, upper stainless steel panel and fixing device are removed after launching. Finally, the sliding plate is connected to a previously embedded steel plate in the deck.

For more information, please refer to VSL Pot bearings and Elastomeric bearings brochures.
**Expansion joints**

**Single element steel expansion joints**
Used in building, pedestrian and vehicular structures to seal the gap between two structures so that they can move independently without adversely affecting each other. The joints are of either aluminium or steel with a flexible seal spanning between them and can accommodate movement ranges between 15 mm to 40 mm.

**Multi element steel expansion joints**
Used in highway and bridge structures with large movements due to the effects of concrete shrinkage, thermal and seismic effects or differential settlement and ground movements. Typical movement ranges from 65 mm per single seal up to 1 m when connected together. VSL services using multiple elements include design, supply, 1st installation and long term maintenance.

**Elastomeric expansion joints**
Elastomeric expansion joints have been designed to work as a single element, to be absolutely tight and long-lasting. These joints allow horizontal, vertical and oblique movements, remaining tight. The elastomeric material properties are such that the bearings are not affected by low temperatures. Capability of impact absorption is kept during winter. The characteristics of this material also allows resistance to wearing and abrasion and resistance against bad weather conditions, chemical products and fire. Typical movement ranges from 40 mm up to 330 mm.
Monitoring should be a simple and economic activity, adapted to each of the specific parts of the structure depending on functional and risk analysis. VSL’s monitoring package is offered as an additional service to provide the client with long-term cost savings. It can be applied to structures and to cables (bridges, buildings) either as ground anchors, post-tensioning tendons, or stay cables.

In-house R&D has placed emphasis on durability method, measurement and sensor configurations, thus allowing to both assess the actual condition of stay cable system components and predict subsequent evolution. The VSL full service monitoring package may be used to assess shrinkage, stress evolution and vibration of the concrete structure weather conditions, traffic, pollution; to send and to follow-up the behavior of the structure, optimise maintenance; to detect damage and confirm diagnosis of deterioration; to validate and memorise know-how for future projects; to optimise life cycle cost of the structure.

As an additional service, the VSL DeMon system allows wireless connection from your office to any type of sensors on site through internet and wireless devices. The system provides real time, 24 hours a day, filtering of the data to detect events, to send an alarm and to analyse only significant events.
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