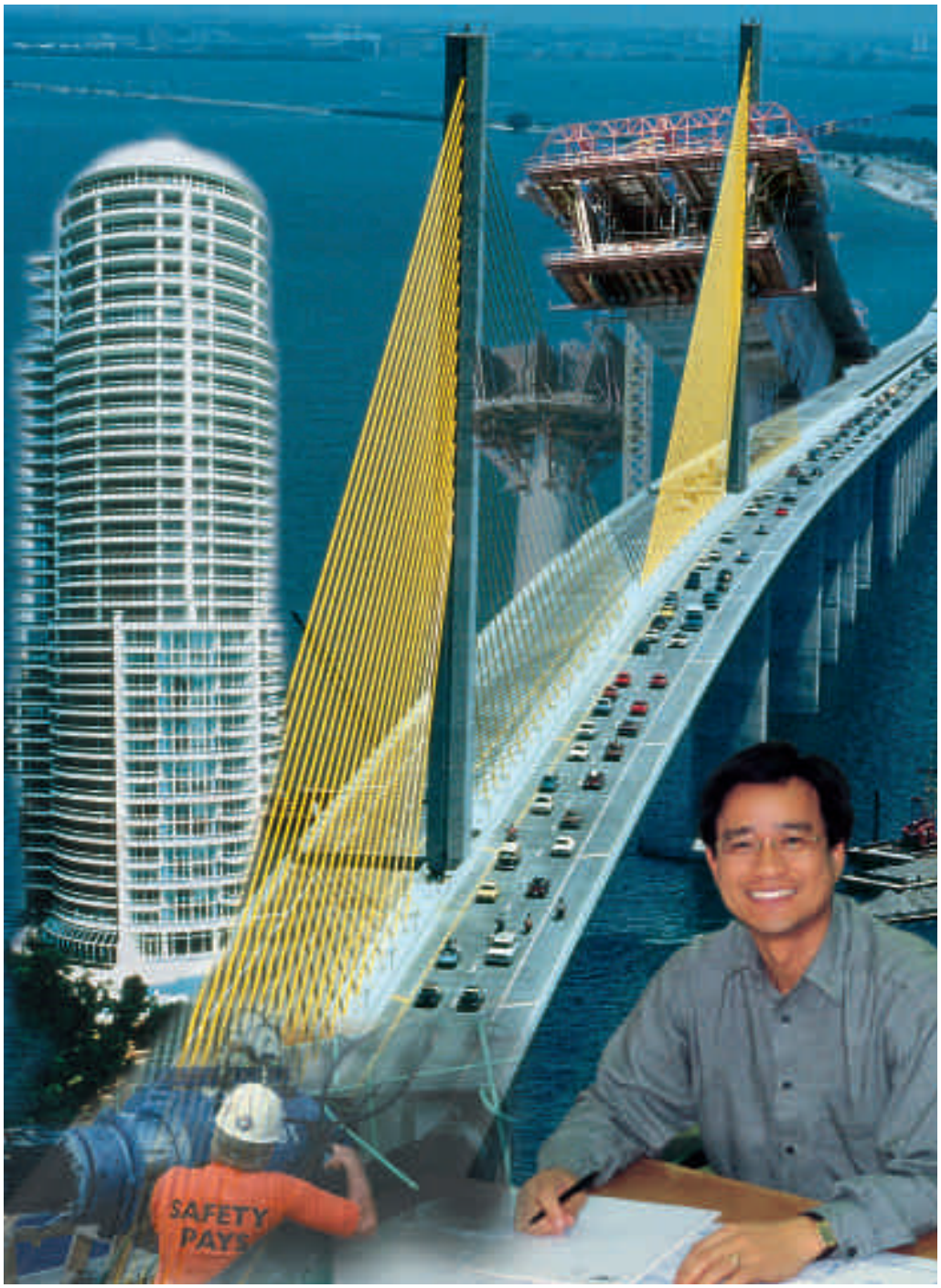
VSL CONSTRUCTION SYSTEMS



POST-TENSIONING

STAY CABLES

STRENGTHENING

HEAVY LIFTING

FORM TRAVELERS

A Structural Group Company

About VSL

As the recognized leader in post-tensioning and related engineering, VSL's construction systems have been used throughout the world since 1956. As a pioneer in introducing post-tensioning technology to the United States, VSL designs, manufactures, and installs post-tensioning systems and components, and provides specialized construction systems.

VSL has utilized these systems to build, repair, and strengthen bridges, buildings, tanks, and special structures throughout the United States. VSL's systems are technically proven and have earned a well-deserved reputation for their quality and reliability.

Post-tensioning is VSL's core business. Multistrand and monostrand systems are used in every area of concrete construction. The post-tensioning principle is also applicable to stay cables and external tendons. VSL's understanding of prestressing has also led to the development of the VSL heavy lifting technique which provides safe and cost-efficient solutions for lifting and lowering of large and heavy loads. In addition, VSL offers form travelers for construction of balanced cantilever concrete bridges.

Clinker Silo - Union Bridge, MD

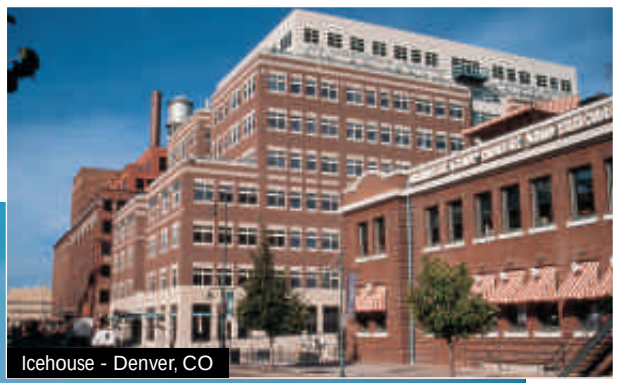
Erie Zone 3 Tank - Erie, CO

Interstate 895 - Richmond, VA

William Natcher Bridge - Owensboro, KY

VSL provides technical support during the planning and construction phases of projects. Our comprehensive range of services includes feasibility studies, preliminary designs, alternative proposals, detailing, project coordination, and contractor consulting. VSL can also execute the work utilizing VSL personnel and equipment. These services aim to provide the best solution adapted to each customer's requirements.

As part of the Structural Group, the nation's leading specialty contracting organization, VSL can deliver innovative solutions from operating centers throughout the United States. The Structural Group businesses perform a wide range of projects involving the construction, repair, strengthening and protection of industrial facilities, commercial properties, public infrastructure, and municipal structures. For additional information on Structural Group, please visit www.structural.net.



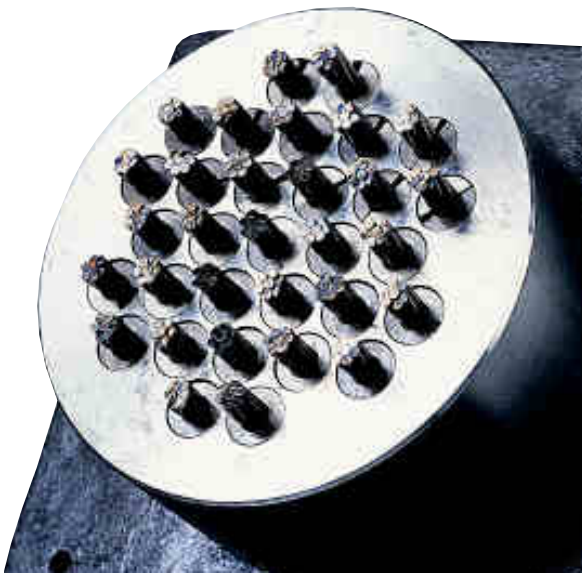
Icehouse - Denver, CO

Sunshine Skyway - Tampa-St. Petersburg, FL

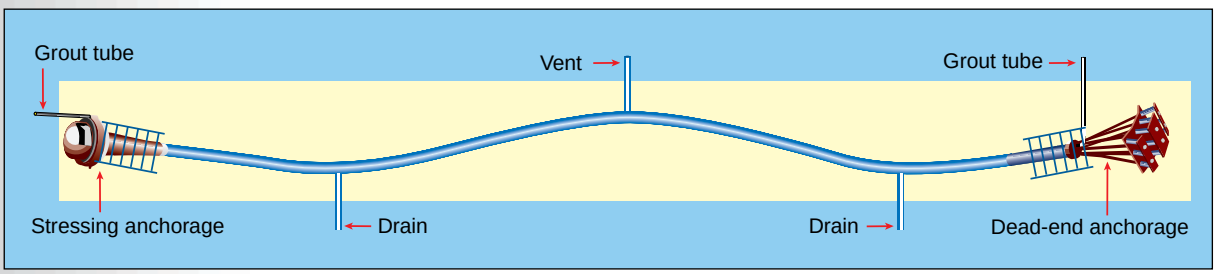
Multistrand Post-Tensioning

The VSL Multistrand System is characterized by the following features:

- standardized tendon units using up to fifty-five 0.5" (13mm) or 0.6" (15mm) diameter strands;
- wide selection of anchorage types;
- steel or plastic PT-PLUS™ ducts;
- high-performance cement or other types of grouting;
- tendons manufactured on-site or in the plant;
- no need to determine tendon length in advance;
- simultaneous stressing of all strands in a tendon;
- stressing carried out in any number of phases;
- simple and reliable equipment for installation, stressing and grouting.



VSL Multistrand System Components



VSL Anchorages

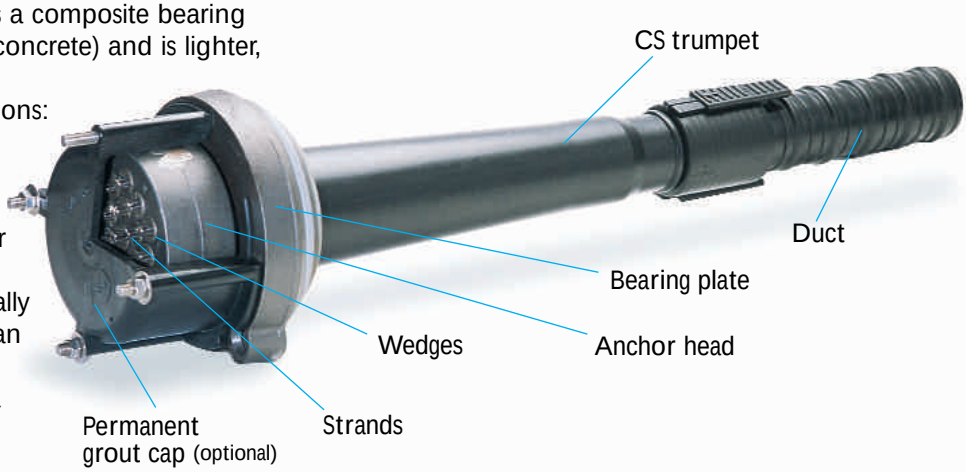
Technical data and dimensions are provided in the Appendix.

For clarity and simplicity, spirals are not shown in the pictures. However, they form an integral part of the anchorage. For more detailed information, see VSL's Report Series on "Detailing for Post-Tensioning."

The SO, SA and VSLAB+® are our standard anchorages for bonded slab post-tensioning. They are also often used for bridges, buildings, tanks and other structures.

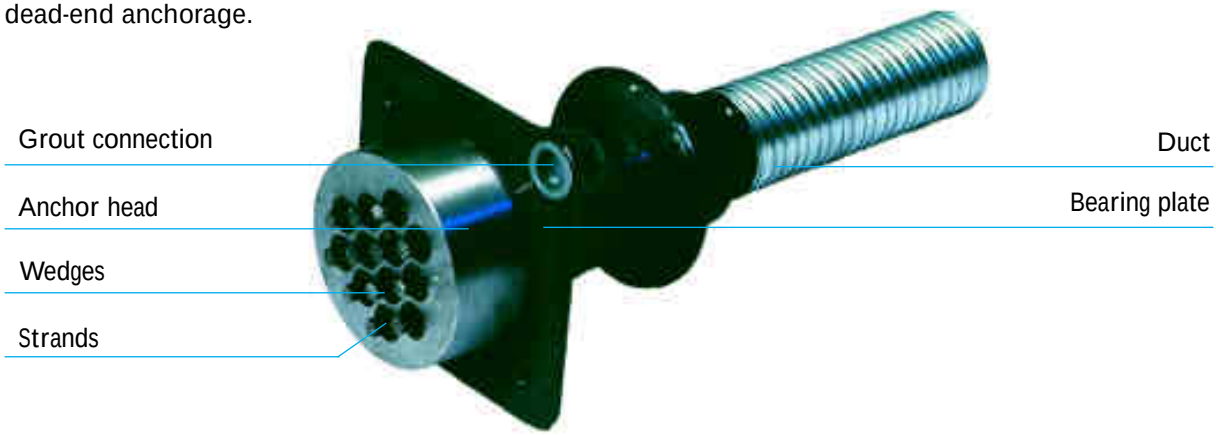
Stressing Anchorage: VSL Type ES

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: ES - STANDARD for normal applications, ES - PLUS using VSL's PT-PLUS™ duct system for enhanced corrosion protection or improved fatigue resistance, and ES - SUPER to provide an electrically isolated tendon. Equipped with an additional retainer plate, the ES anchorage can also be used as a dead-end anchorage.



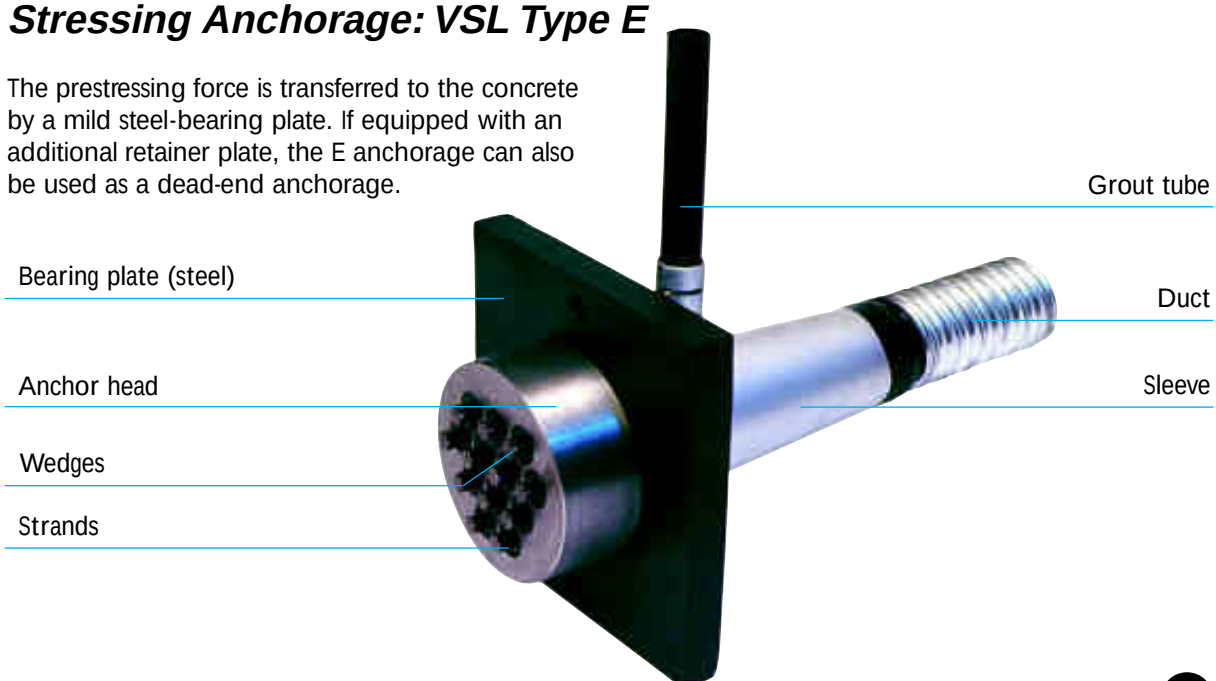
Stressing Anchorage: VSL Type EC

This compact and easy to handle anchorage system allows prestressing force to be transferred through two flanges. If equipped with an additional retainer plate, the EC anchorage can also be used as a dead-end anchorage.



Stressing Anchorage: VSL Type E

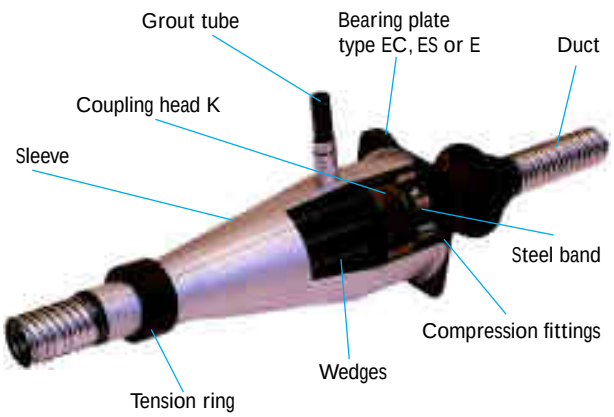
The prestressing force is transferred to the concrete by a mild steel-bearing plate. If equipped with an additional retainer plate, the E anchorage can also be used as a dead-end anchorage.



Multistrand Post-Tensioning

Coupler: VSL Type K

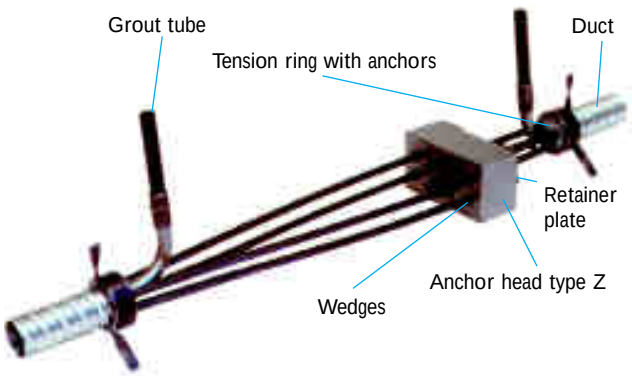
This fixed coupler is used for connecting to a tendon that has already been installed and stressed. The strands are anchored using compression fittings positioned onto the coupling head grooves.



Intermediate Anchorage: VSL Type Z

Intermediate anchorages are used for those tendons where the ends cannot be anchored using normal stressing anchorages. The anchor head is loosely placed in the blockout and moves during the stressing operation on the tendon axis. Z type intermediate anchorages are used:

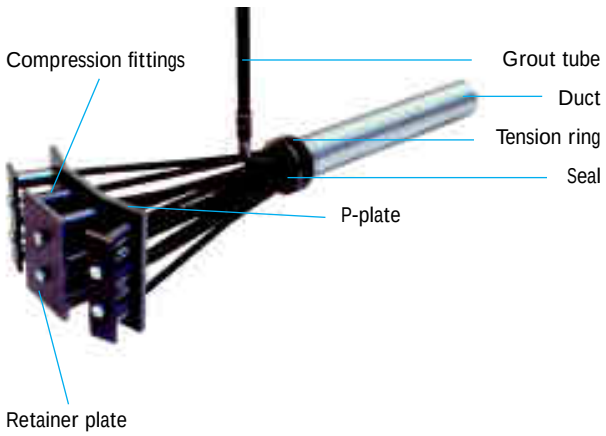
- for pressure shaft and pressure tunnel ring tendons, avoiding the use of internal buttresses;
- for silo and reservoir circular structure ring tendons, avoiding the use of external buttresses;
- for transverse bridge deck prestressing where, for aesthetic reasons, external anchorage blockouts are undesirable;
- for frame, arch and shell structure tension ties where there is no or limited access to end anchorages.



Dead-End Anchorage: VSL Type P

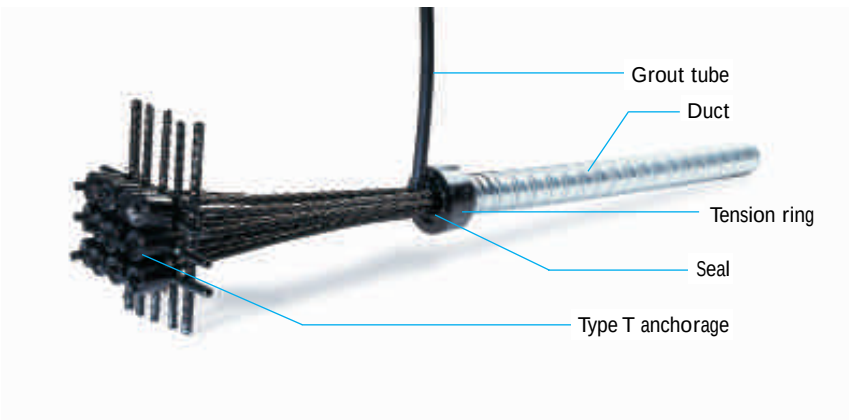
This type of anchorage is used where the prestressing force has to be transferred to the structure at the far end of the tendon. It consists of a folded plate incorporating holes for the strands to pass through. The strands are anchored using compression fittings bearing on the plate. The compression fittings are locked into position by a retainer plate.

Where the force can 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.



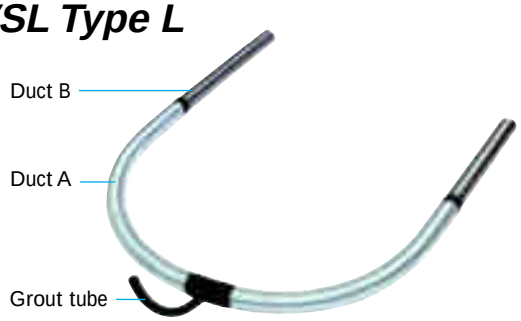
Dead-End Anchorage: VSL Type T

The transfer of the prestressing force is partially achieved by bonding the strands to the concrete, and partially by the individual anchor casting. The spiral and tension ring confine the stresses due to deviated forces acting on the concrete.



Multistrand Post-Tensioning

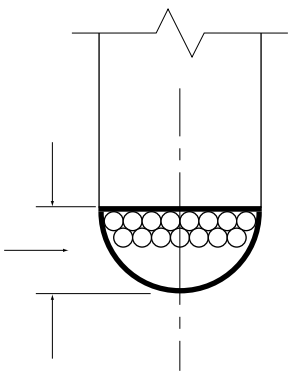
Dead-End Anchorage: VSL Type L



This type of anchorage is used for tendons installed after the concrete is placed and where there is no access to the dead-end. It is often used for vertical tendons in reservoir walls, for connecting pier segments to piers in segmental bridge construction, or for horizontal tendons in slabs or foundation mats. The strands are installed into the duct after concrete placement and simultaneously stressed using jacks at both ends.

Dead-End Anchorage: VSL Type LD

When loops with a smaller radius are required, VSL Type LD Loops are available with a 23" (584mm) radius. The tendon sizes available are the same as Type L – the difference is in duct configuration as indicated.



Duct sized such that only two (2) layers of strand occur in the loop.

Dead-End Anchorage: VSL Type AF

This type of anchorage is used for vertical tendons that must be installed after concrete placement 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 tendon is grouted in two stages. The strands, with compression fittings at their ends, are bonded to the load-transferring casting using special cementitious grout. After stressing, the tendon is grouted.

Sheathing and Corrosion Protection

Generally, corrugated steel ducts with a minimum wall thickness of 26 gauge are used.

However, the VSL PT-PLUS™ System with its corrugated duct and plastic coupler can provide a number of important advantages when compared with conventional ducts, such as:

- greatly enhanced tendon corrosion protection;
- improved tendon fatigue resistance;
- reduced sensitivity to stray electric currents;
- reduced tendon friction;
- electrical isolation when used with special ES anchorages.

The PT-PLUS™ System is suitable for all applications but, given its specific characteristics, is best adapted to:

- transverse tendons in bridge deck slabs;
- tendons that are close to the concrete surface;
- railway bridges and other structures that are subject to fatigue loadings or stray electric currents;
- structures where a severe corrosive environment may be expected;
- tendons that need to be electrically monitored throughout the structure's service life.

Selected Design Considerations

Tendon Force Losses

The effective prestressing force at a specific place and time differs from the initial prestressing force for various reasons.
Significant factors include:

- friction losses in the anchorage;
- friction losses due to curvature of the tendon;
- shrinkage and creep of the concrete;
- relaxation of the prestressing steel;
- draw-in of the wedges during lock-off;
- elastic shortening of the structural element.

The friction losses in the anchorage due to curvature of the strand and friction of the strand in the wedges usually amount to between 2 and 4% of the jacking force, depending upon the type of anchorage and tendon unit.

The friction losses along the tendon can be determined using the following formula:

$P_x = P_o e^{-(\mu\alpha + kx)}$

x = distance from stressing end (in feet or meters);
P_x = prestressing force at x;
P_o = prestressing force at stressing end;
μ = coefficient of friction;
α = sum of all angular deviations (in radians) over the distance x;
k = wobble friction coefficient due to minor unavoidable tendon curvatures (placing tolerances) per ft (m).

The friction coefficients μ and k can vary and depend upon various factors, including: the nature and surface condition of the prestressing steel; the type, diameter and surface condition of the duct; the installation method; and tendon radius of curvature.

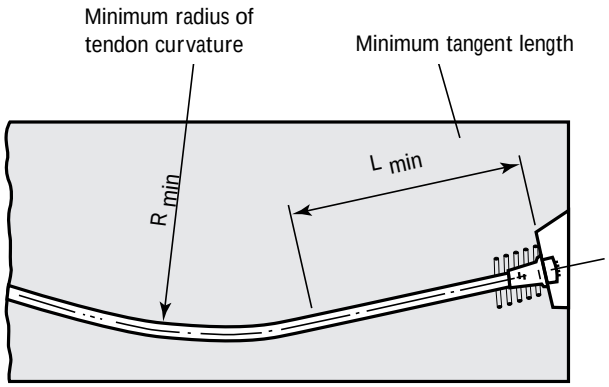
The following values may be assumed for design:
Tendon in standard circular galvanized steel ducts:
μ = 0.20
k = 0.0002/ft (0.0007/m)
Tendon in circular PT-PLUS™ plastic ducts:
μ = 0.14
k = 0.0002/ft (0.0007/m)

For calculating the losses due to shrinkage and creep of the concrete, reference should be made to the technical literature and to the standards applicable to each project.

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

For low relaxation strands commonly used today, the maximum loss is 2.5% after 1,000 hours at 68°F (20°C) and an initial stress of 70% of the nominal tensile strength. Further information can be found in the relevant prestressing steel standards and manufacturer's literature.

Independent of the type of VSL jack or tendon, a loss due to wedge draw-in of approximately 0.25" (6mm) occurs at lock-off. If necessary, this can be compensated by suitable procedures.



Tendon Unit	R min. ft.	R min. m	L min. ft.	L min. m
5-7	9.8	3.0	2.6	0.8
5-12	13.5	4.1	3.3	1.0
5-19	17.7	5.4	3.3	1.0
5-27	21.0	6.4	3.3	1.0
5-31	22.3	6.8	4.9	1.5
5-37	24.0	7.3	4.9	1.5
5-43	25.9	7.9	4.9	1.5
5-55	29.5	9.0	4.9	1.5
Tendon Unit	**R min. ft.**	**R min. m**	**L min. ft.**	**L min. m**
6-7	12.8	3.9	3.3	1.0
6-12	16.4	5.0	3.3	1.0
6-19	20.7	6.3	4.9	1.5
6-22	22.6	6.9	4.9	1.5
6-31	26.4	8.1	4.9	1.5
6-37	28.2	8.6	4.9	1.5
6-43	30.8	9.4	4.9	1.5
6-55	34.8	10.6	4.9	1.5

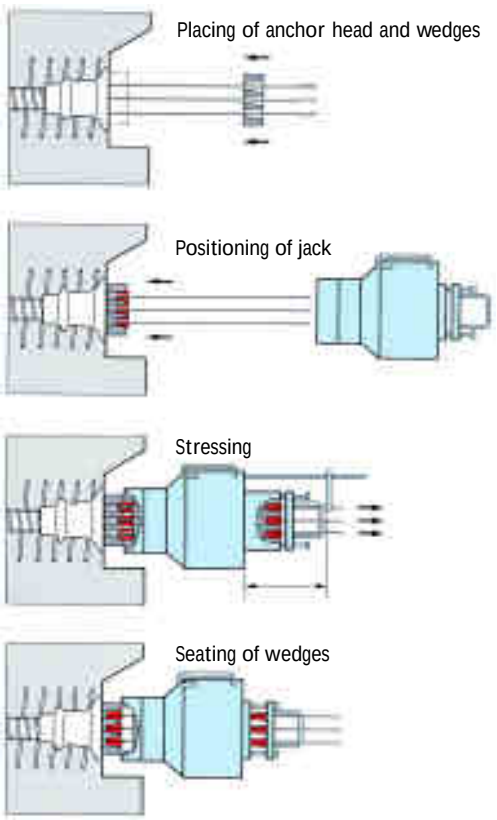
Tendon Supports

Recommended spacing:
Standard steel ducts: 2.5 to 4.0 ft (0.8 to 1.2m)
PT-PLUS™ plastic duct: 2.0 ft. maximum (0.6m)

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.




Placing of anchor head


Positioning of jack


Stressing, measuring, seating of wedges

Grouting

The objectives of the VSL Grouting System are to prevent corrosion of the prestressing steel by filling of all voids and cavities in the tendon and to fully encapsulate the steel in an alkaline environment, as well as achieve an effective bond between the prestressing steel and the surrounding concrete member. This is achieved through:

- Careful selection of cement, water, and admixtures;
- Continuous quality assurance and quality control processes and measurement;
- Selection of mix design and procedures adapted to the selected materials, environment and equipment;
- Performance of the grouting by trained VSL Grouting Technicians.


Grouting of tendon

Bonded Slab Post-Tensioning

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 beam 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 slabs, free designers from the limitations of conventional reinforced concrete structures.

The VSL Bonded Slab Post-Tensioning System has been used in many buildings and structures throughout the world. The system uses up to five strands contained in flat-shaped ducts, and anchorages. Strands are individually stressed and gripped by wedge action. After stressing, the ducts are filled with cement grout that fully bonds the strands to the surrounding concrete.

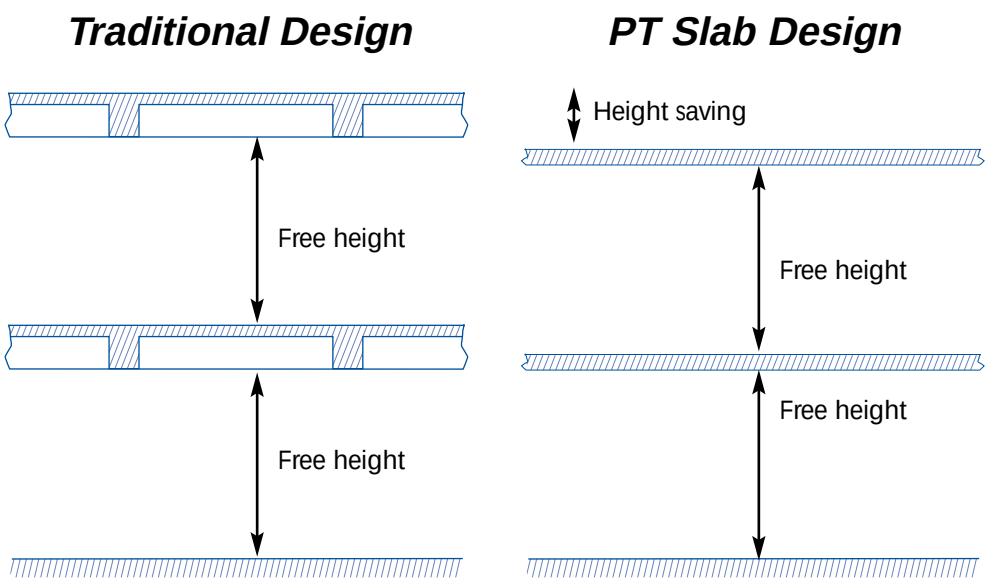
Cottonwood - Salt Lake City, UT

Mt. Rushmore - Keystone, SD

Bonded Slab Post-Tensioning

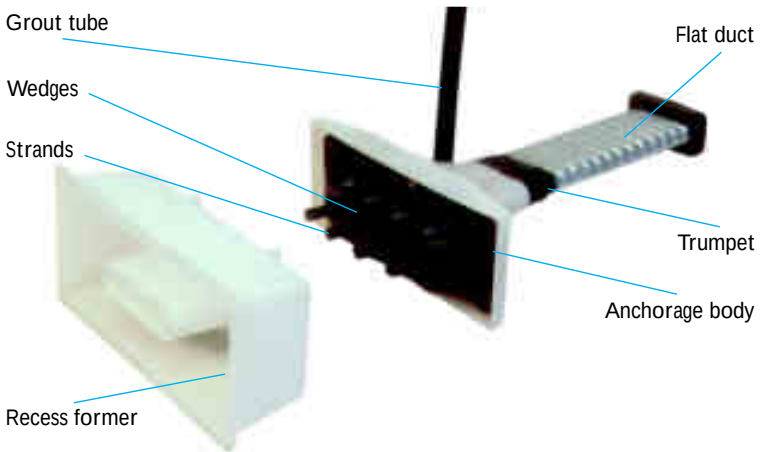
Selected Design Considerations

- Spacing of tendon supports: 2.5 ft to 4 ft (0.8 to 12m) (conventional steel ducts)
  2 ft (0.6m) (PT-PLUS™ plastic ducts)
- Minimum curvature radius: 8 ft (2.5m) (vertical profile)
  50 ft (15m) (horizontal profile)
- Minimum straight length at anchorage: 2.5 ft (0.8m)
- A wedge draw-in of approximately 0.25 in. (6mm) occurs at lock-off
- Friction losses can vary fairly widely from one tendon to another and from one structure to another. This depends on factors such as surface condition of strands, duct types and surface condition, material properties, installation methods and on-site workmanship. The following values may be assumed for design.
  - Tendons in standard steel ducts: μ = 0.20
    k = 0.0002/ft (0.0007/m)
  - Tendons in plastic ducts: μ = 0.14
    k = 0.001/ft (0.0033/m)

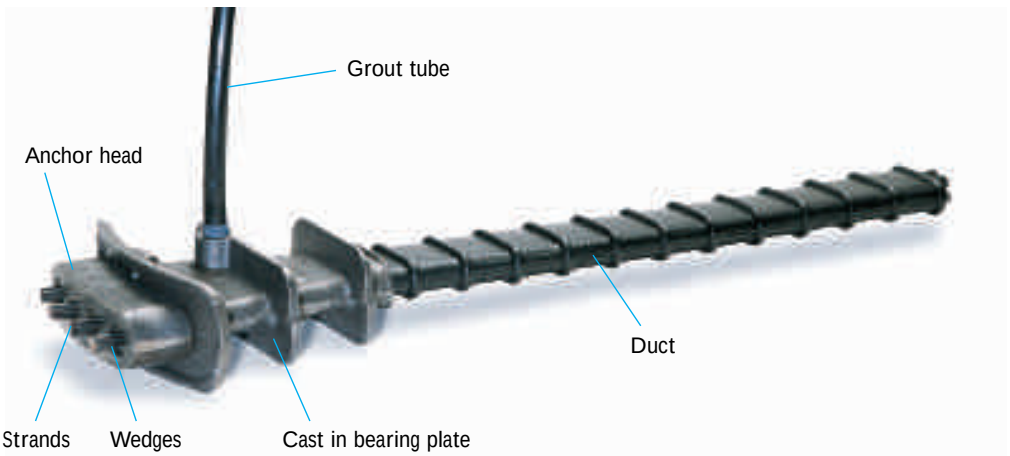


The PT slab method allows designers to reduce building heights or to increase free heights between floors.

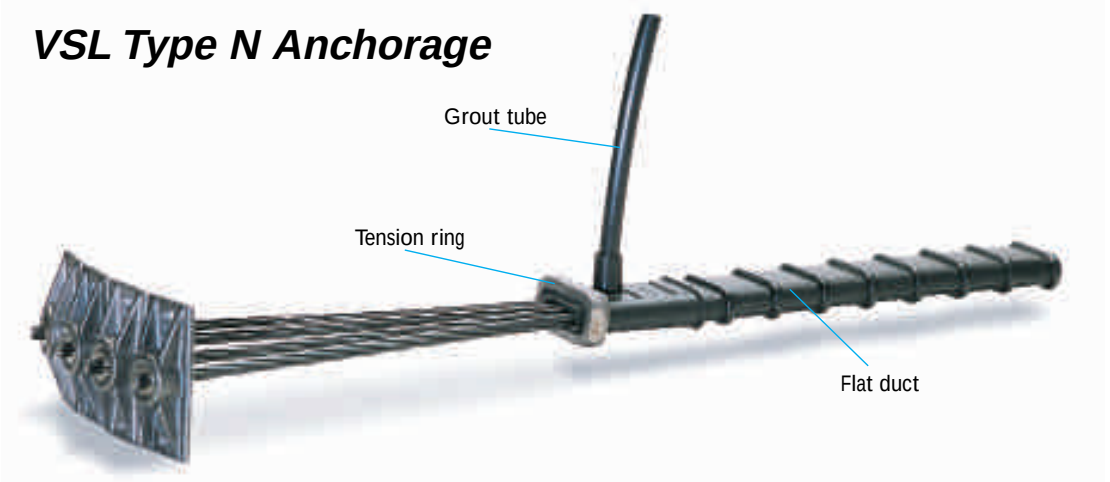
Stressing Anchorage: VSL Type SO



VSL Type SA Anchorage



VSL Type N Anchorage



VSL requires pre-placement of strand in flat duct tendons prior to concrete placement.

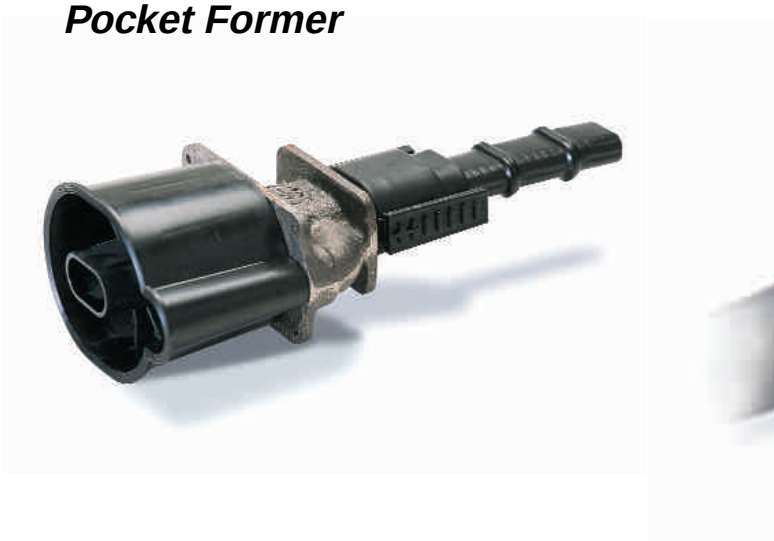
Bonded Slab Post-Tensioning

VSLAB+® System

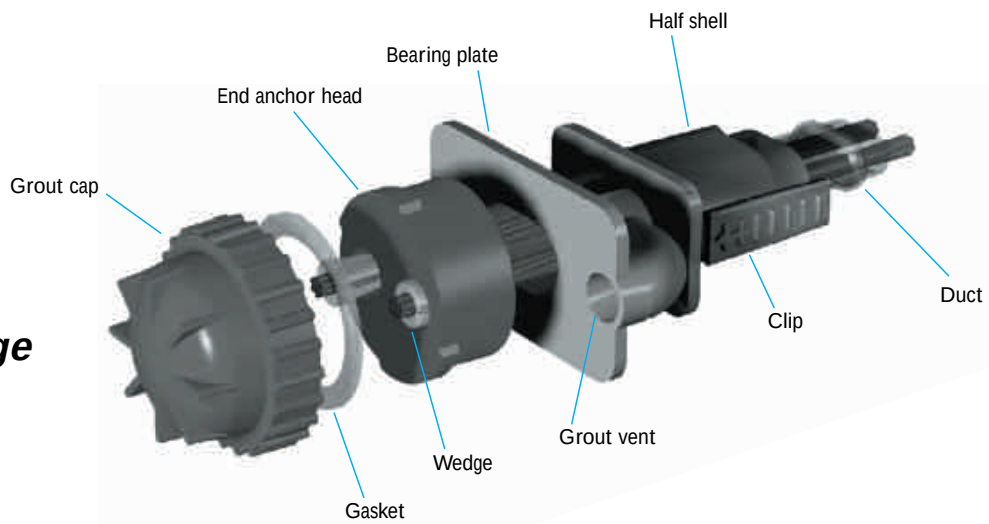
With the VSLAB+® System, the post-tensioning strand is protected by a high performance grout and a true encapsulation system. The grout vents do not exit on the slab wearing surface, but only at the slab edge. The slim design of the bearing plate will easily fit in a 5.5 inch (140mm) thick slab. VSL field technicians ensure proper placement, stressing and grouting of the VSLAB+® System.

The patented VSL Venturi System ensures complete grout filling at the intermediate anchorage locations.

Bearing Plate with Pocket Former

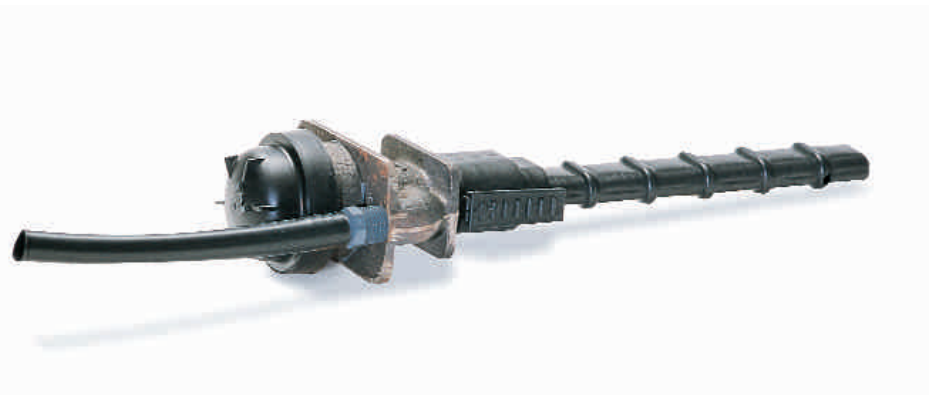


End Anchorage

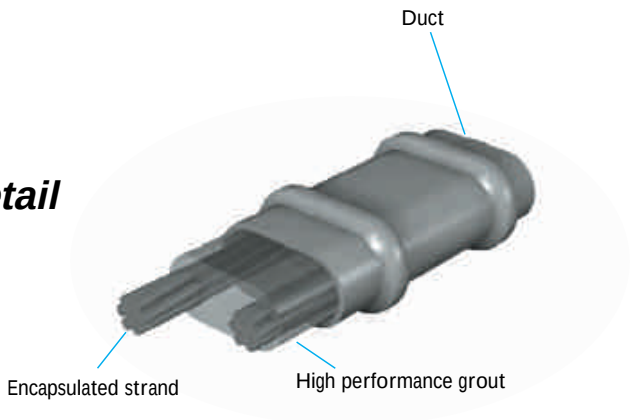


Coupler Assembly (Intermediate)

Stress End with Vent



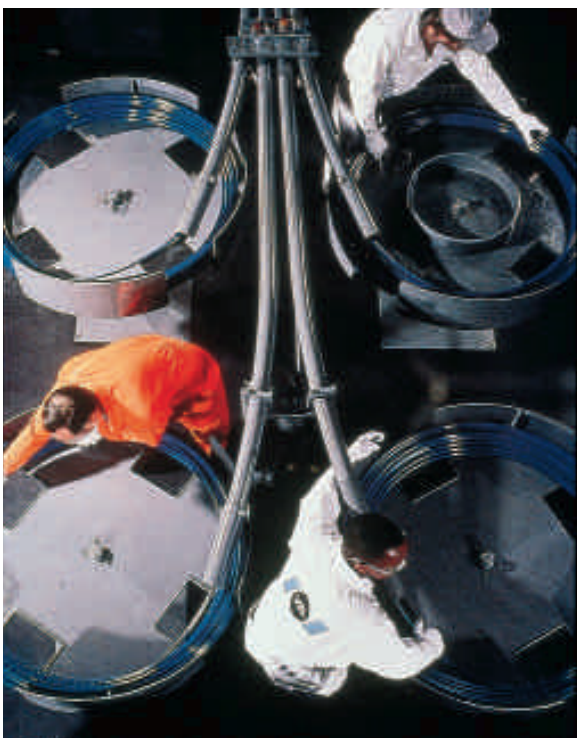
Grout Detail



Monostrand Post-Tensioning

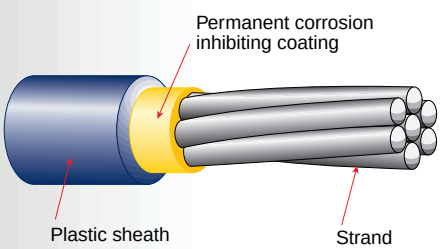
Bristol Towers - Miami, FL

The VSL Monostrand System has advantages similar to those of the VSL Bonded Slab Post-Tensioning System. The VSL Monostrand system uses 0.5" (13mm) and 0.6" (15mm) diameter strands. The strands are given a coating of permanent corrosion-inhibiting coating and are enclosed in an extruded plastic sheath. The grease and plastic provide double corrosion protection, as well as preventing any bonding between the strands and the surrounding concrete.The plastic sheath is polyethylene with approximately 50 mil wall thickness. To ensure continuous corrosion protection in aggressive environments, special sleeves are used to join the sheaths to the anchorages and each anchorage is provided with a protective cap. The VSL Monostrand System features factory-applied corrosion protection, very low friction losses, and full utilization of the structural depth. These light, flexible monostrands can be easily and rapidly installed, leading to economical solutions. Detailed information is given in VSL's "Post-Tensioned Slabs" publication. With modifications, the VSL Monostrand System can also be used for post-tensioning masonry walls.



Monostrand Specifications:

- 0.5" (13mm) and 0.6" (15mm) diameter strand in accordance with ASTM A 416.
- permanent corrosion-inhibiting coating and plastic sheath in accordance with PTI recommendations.



Recommended Design Values

Spacing of tendon supports: 2 ft to 5 ft (0.6 to 1.5m)
Minimum curvature radius: 8 ft (2.5m)

The following friction cœfficients may be assumed:
μ = 0.05
k = 0.0014/ft (0.0046/m)

Reinforcement of the Anchorage Zone

In addition to the slab reinforcement required by the design, additional reinforcement is necessary in the force distribution zone behind each anchorage. Details should be established by the project engineer.

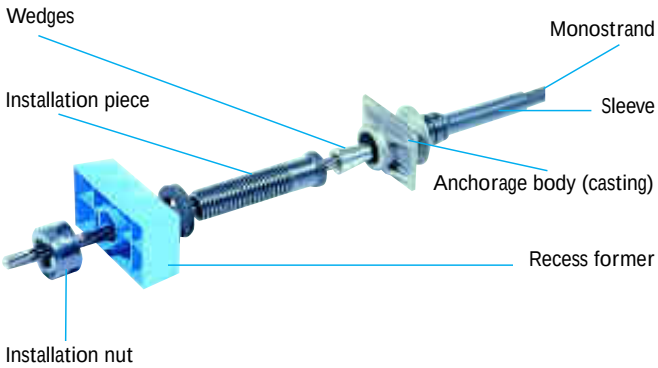
Stressing Jacks

Twin ram jack

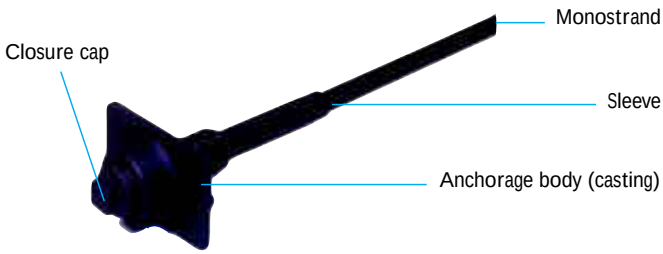
VStrand™ Heat Resistive Tendon

VSL's innovative heat-resistive post-tensioning tendons have been developed to mitigate the detrimental thermal effects of a fire on the strength of the prestressing steel. Each tendon consists of one or more steel prestressing strands coated with a proprietary intumescent material. This coating provides a significantly greater degree of protection to the strand in the event of a fire. These tendons are particularly well suited for strengthening of parking garages and other structures that are exposed to vehicular fires.

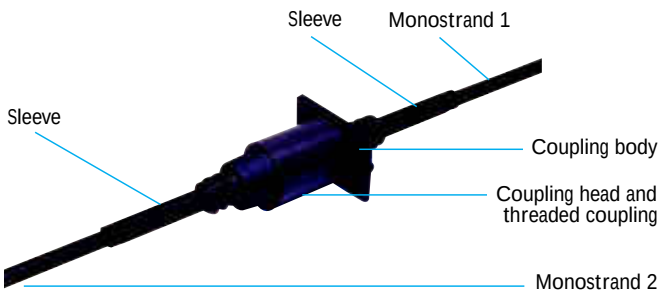
Stressing Anchorage: VSL Type S-6



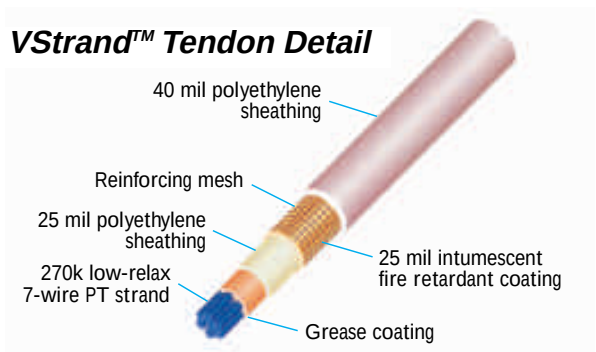
Dead-End Anchorage: VSL Type SF-6



Coupler: VSL Type SK-6



VStrand™ Tendon Detail



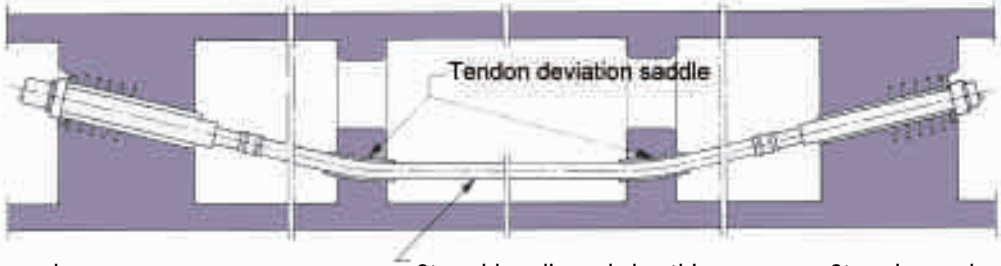
External Post-Tensioning

External post-tensioning is well adapted to bridges due to the resulting savings in construction costs 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:

- strand bundle;
- polyethylene ducts;
- standard multistrand anchorages, or special anchorages permitting easy tendon replacement;
- grout.

VSL External Post-Tensioning System Components



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 transverse forces that the tendon applies to it and transmit these forces to the structure;
- ensure, without unacceptable angular breaking, the connection between two straight tendon sections;
- withstand movements of the external tendon during stressing without compromising the tendon's corrosion protection system.

When designing saddles, it is important to consider the following:

Various solutions have been used in practice, as shown on 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 sheathing be properly joined. If tendon replacement is a design requirement, the saddle arrangement must be chosen accordingly; i.e., double sheathing as shown on alternative (3) of the sketch below or by the use of a "Diablo" as shown on the alternative (4) of the sketch.

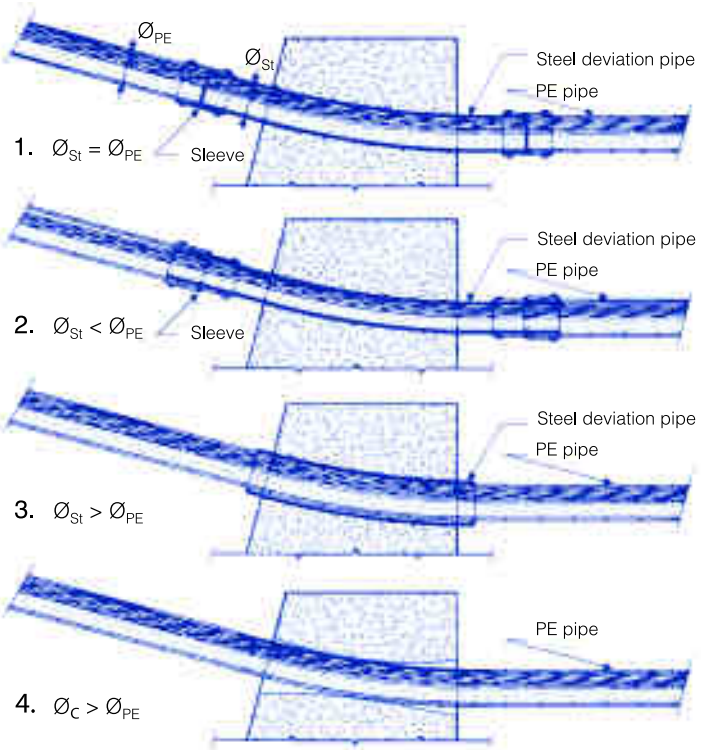
Minimum Tendon Radii

Minimum tendon radii as recommended in Table 1 must be followed in order to avoid damage to the prestressing steel and the plastic sheathings, 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

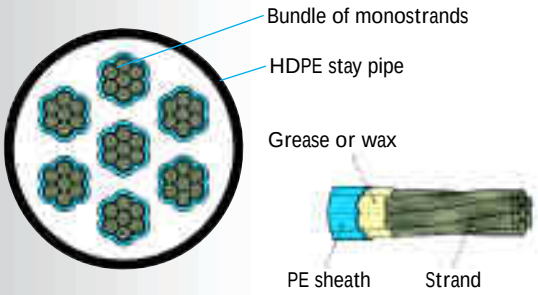
Tendon size (VSL tendon unit)	Minimum radius (ft) (m)	
up to 5-19 or 6-12	8 ft	2.50m
up to 5-31 or 6-19	10 ft	3.00m
up to 5-55 or 6-37	13 ft	4.00m

Saddle Arangements



Stay Cables

VSL Stay Cable System SSI 2000



VSL Stay Cable System

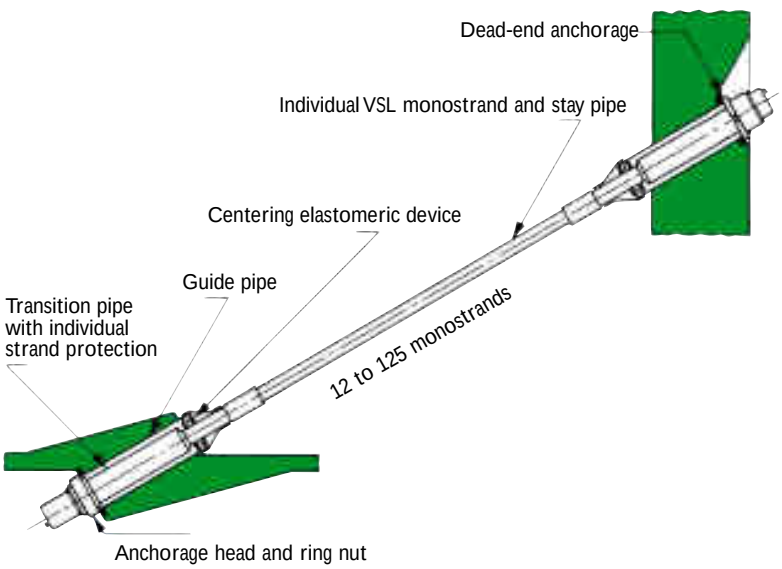
The VSL Stay Cable System was developed to meet the stringent design, construction and maintenance requirements of cable-stayed bridges. The VSL Stay Cable System includes:

- a tendon formed from multiple and parallel 0.6" (15mm) diameter high tensile 7-wire steel strands;
- a greased extruded plastic coating to each strand;
- an outer plastic stay pipe;
- factory prefabricated anchorages.

The system features are as follows:

- 29.0 ksi (200 MPa) high 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 future installation of anti-vibration dampers.


Sunshine Skyway - Tampa-St. Petersburg, FL




Foss Waterway - Tacoma, WA

Compactness

The reduced size of the anchorage components allows for easy installation and savings in the cost of the structure.

Aesthetics

- using colored co-extruded stay pipes, different colors can be obtained;
- vibration damping devices can be placed inside guide pipes or stay pipes.

Dynamic Stability of the Cables

- stay pipes can be equipped with external helical ribs to suppress rain-wind induced vibrations;
- the stay cable system is easily modified for the future installation of anti-vibration dampers.


C&D Canal - Delaware

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.

Reduced Maintenance Costs

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

Stay Cable Installation

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

Strengthening Systems

VSL Strengthening Systems provide economical solutions for structures requiring load capacity upgrade or improvement due to change of use, deterioration, or construction defects.

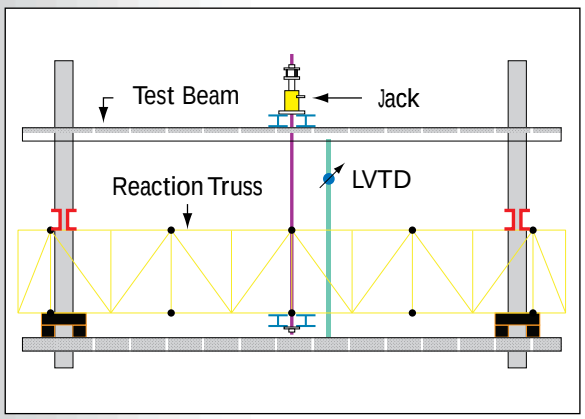
Turnkey Solutions

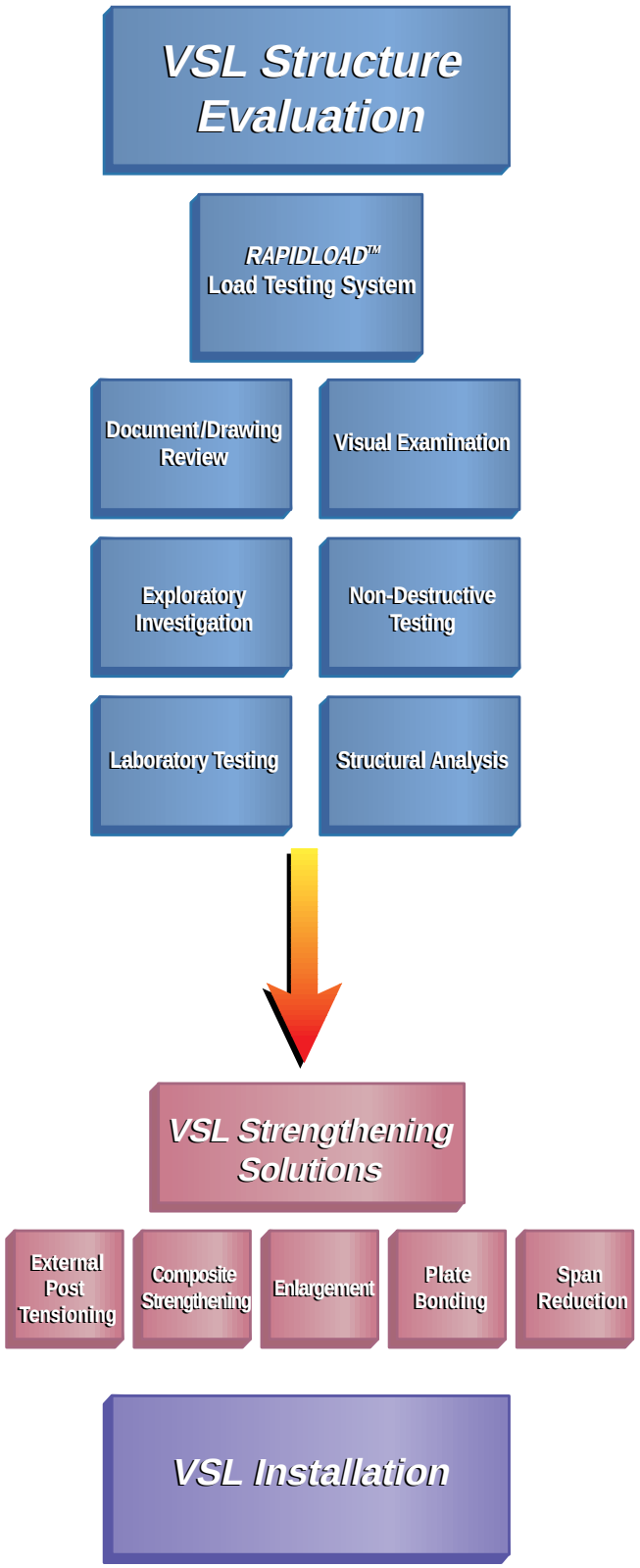
VSL is a one-source solution for structural upgrades. Our systematic approach to the analysis, load test design and execution of strengthening projects allows us to integrate our engineering, manufacturing and installation capabilities into a creative, efficient, timely and cost-effective approach.

VSL Structure Evaluation

RapidLoad™ Test

The RapidLoad™ testing procedure can be performed to assess the capacity in a structural member that will undergo a change in use or to qualify the level of damage or deterioration that has occurred to that member. RapidLoad™ test may also be used to establish the service levels of a unique design or verify the adequacy of a proposed strengthening solution.





VSL Strengthening Solutions

VSL provides innovative solutions for increasing the flexural, axial and shear capacity of structural elements. These proven solutions may include the following:

VSL External Post-Tensioning Systems

VSL utilizes multistrand and monostrand systems in unique and practical ways to provide active strengthening systems to structures. VSL engineers develop custom solutions to each strengthening project. Post-tensioning system designs may be internal or external to the existing structure and consist of standard or custom VSL multistrand, monostrand and VStrand™ tendons and anchorage assemblies. VSL post-tensioning systems for flexural, shear and axial strengthening applications are applicable to concrete, steel and composite structures in buildings, bridges, tunnels, tanks, silos and other structures.

Composite Strengthening Systems

VSL advanced composite strengthening systems provide an economic solution to challenging strengthening projects. VSL engineers provide solutions utilizing high-strength, durable advanced composite materials including high-strength, corrosion-resistant carbon, E-glass and aramid fibers which can be fabricated into sheets, bars, rods and plates. These systems are installed by trained VSL field technicians. Each strengthening project is designed and planned in detail and executed in strict compliance with our advanced composite system quality assurance program. These systems are appropriate for the flexural, shear and axial (confinement) applications.

Enlargement and Overlays

These systems increase capacity by increasing the load-carrying section properties of the structural member. VSL engineers carefully design and detail solutions to provide flexural, axial and shear upgrades using reinforced concrete and steel systems.

Plate Bonding and Bolting

These engineered solutions utilize steel or advanced composite plates bonded to properly prepared substrate with epoxy, bolts or combined load transfer systems. Plate systems may also be unbonded with transfer of forces through bolted connections.

Span Shortening

This is a strengthening technique that utilizes an engineered approach to reduce the stress in a structural member by reducing the unsupported length of that member.


1


2


3


4


5


6


7


8

1) Strengthening of the ring beam for a concrete dome using external post-tensioning.

2) Steel plate bonding of an arched bridge.

3) Plate bonding and external post-tensioning of a parking garage.

4) Two-way slab upgrade using FRP.

5) Installation of carbon fiber rod in a storage silo.

6) Steel punching shear assembly added to a column.

7) Steel moment connection.

8) Beam enlargement for added shear capacity.

Heavy Lifting

Winfield Lock and Dam - Winfield, WV

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.

Innovative Solutions

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

Escondida Copper Mine - Chile

Safety

The safety of your personnel and work site is VSL's first priority. Our specialized 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.

The 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

The 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 center 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 piston's 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 may be equipped with an auxiliary device which automatically controls the opening and closing of the anchorages.

Tensile Member

The tensile member consists of 7-wire prestressing steel strands with a 0.6" (15mm) nominal diameter. 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 synchronized movement

Seven Mile Bridge - Florida

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 65 ft (20m)/hr.

Control & Monitoring Systems

The lifting of hangar roofs or of similar statically indeterminate structures usually requires that lifting movements be precisely coordinated. 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.

Form Travelers

The VSL Form Traveler System is used for construction of balanced cantilever concrete bridges. The form traveler system is designed to provide a rigid frame to minimize deflections under load. VSL provides a custom engineered, highly flexible form traveler system for a variety of segment lengths, depths and structure configurations.

System Flexibility

The VSL Form Traveler System is designed for a variety of segment lengths up to 16.5' (5m), and can support concrete and formwork loading up to 450 tons. The traveler 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 traveler assembly are typically less than 1" (25mm) at maximum loads.

Interstate 895 - Richmond,VA

Interstate 205 - Portland, OR

H-3, North Halawa Valley Viaduct, Hawaii

System Operation

The VSL Form Traveler System is economical and efficient to use. The traveler is designed with pinned connections for simplicity of erection and dismantling. 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 4-5 days. 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, leveled 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 leveled and fixed into place.
5. Reinforcing steel and post-tensioning tendons are placed in the deck slab.
6. Concrete is placed in the bottom slab, web walls, and deck slab.
7. The post-tensioning tendons are stressed.
8. The internal and external formwork is stripped from the cast and cured segment, and the VSL Form Traveler is launched to the next segment.

Wabasha Street Bridge - St. Paul, MN

Interstate 895 - Richmond,VA

Interstate 205 - Portland, OR

VSL Services

VSL provides a variety of design, fabrication, material and installation services to the balanced cantilever construction process. Our engineering team supports the custom design of the Traveler System to meet the needs of a specific project and bridge configuration. Complete system drawings and operation manuals detail all aspects of traveler operation for ease of assembly and safe operation. VSL is ready to provide technical assistance and field supervision of traveler erection, launching, maintenance and dismantling. VSL construction forces can also provide an expanded scope of services to include the supply and installation of the reinforcing steel, formwork and post-tensioning systems.

One Source, Many Solutions

Structural Group delivers services and systems that build, reinforce, repair, strengthen and protect structures and soils. Our companies have completed over 8,000 repair projects; 22,000 post-tensioning projects; and 10,000 chimney, stack and silo projects through the efforts of our people working together in operating centers across the United States.

STRUCTURAL PRESERVATION SYSTEMS

- Concrete Repair • Masonry Repair
- Waterproofing & Protection
- Reinforcement Repair

Since 1976, Structural Preservation Systems has completed over 8,000 repair and protection projects for the commercial, public and industrial markets. By applying new technologies to well-established repair principles, SPS partners with owners and designers to safely deliver cost-effective solutions.

VSL

- Post-Tensioning Systems
- Stay Cable Systems • Form Travelers
- Heavy Lifting

VSL designs, manufactures and installs post-tensioning systems and components in buildings, bridges, tanks and special structures. Technical sophistication and comprehensive support have earned VSL a reputation for quality and reliability throughout the world since 1956.

Pullman Power

- Chimneys, Stacks & Silos • Demolition
- Design & Construction
- Repair & Maintenance

A leading builder of reinforced concrete chimneys and silos, Pullman Power serves customers in power, industrial and other markets. Since 1902, Pullman has managed over 10,000 projects worldwide, including five of the six tallest reinforced concrete chimneys.

STRENGTHENING

- MBrace® Composite Strengthening System
- External Post-Tensioning • Section Enlargement • RapidLoad™ Testing

Whether the need for strengthening arises from change in use, change in code, structural defects or seismic conditions, our Strengthening division utilizes the latest technologies to develop innovative strategies to restore or add load-carrying capacity to buildings, parking facilities and other structures.

GEOSTRUCTURAL

- Settlement Control • Foundation Strengthening • Ground Improvement
- Slope & Dam Stabilization

With an extensive knowledge of soils and structures, GeoStructural develops and implements efficient solutions to underground challenges. The GeoStructural division of SPS is ready to tackle emergency and long-term projects through a wide variety of geotechnical methods.

INDUSTRIAL SERVICES

- Condition Assessment • Structural Repair & Strengthening • Protective Coatings
- Polyshield® Foundation/Baseplate System

Structural Preservation Systems' Industrial Services team upgrades and repairs facilities safely and cost-efficiently to minimize downtime. Our skilled teams develop safety-oriented solutions for challenging environments to provide turnkey project delivery.

A Structural Group Company

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DALLAS, TEXAS
1609 109th Street
Grand Prairie, Texas 75050
972-647-0200
Fax: 972-641-1192

DENVER, COLORADO
4825 Van Gordon Street
Wheat Ridge, CO 80033
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