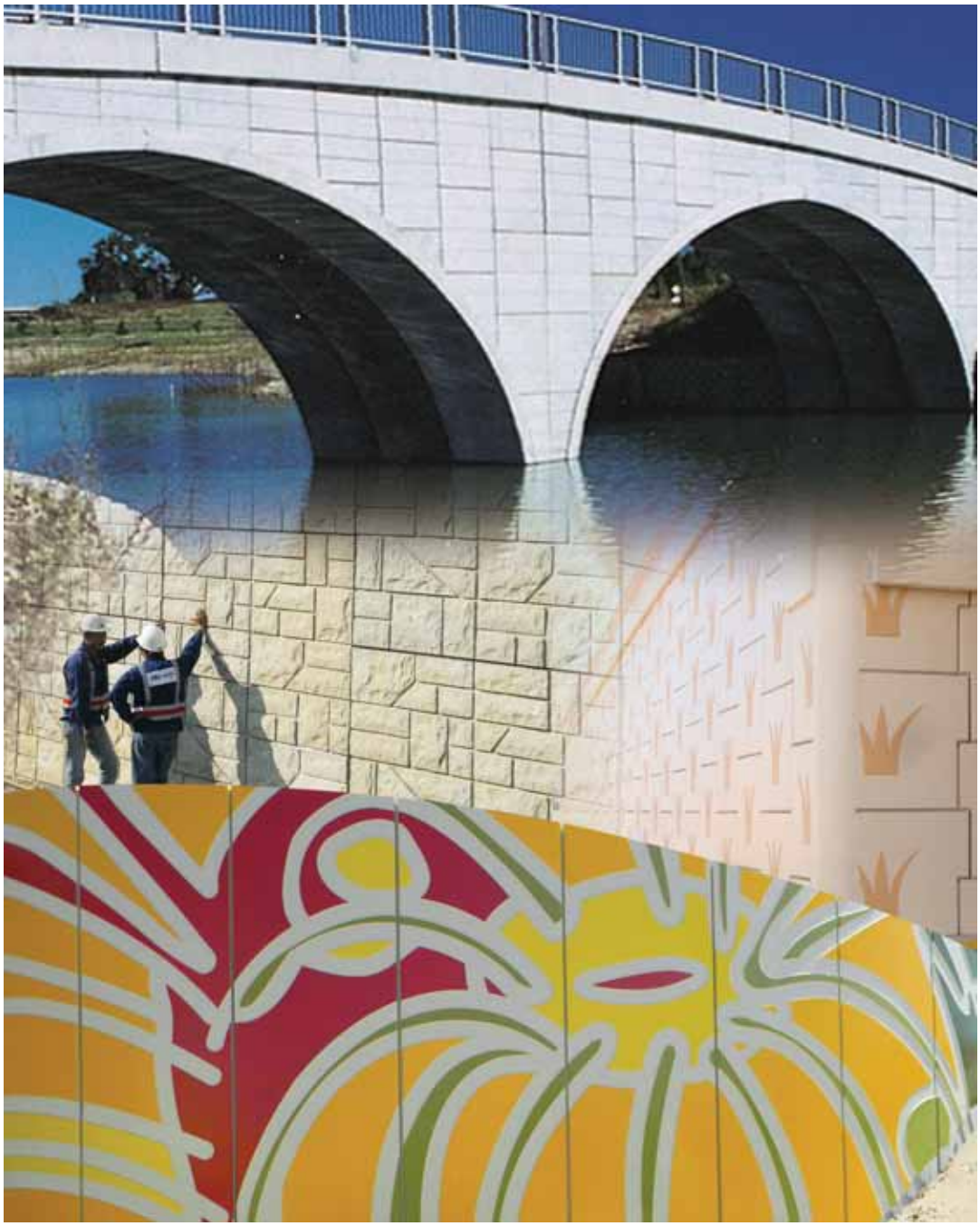
VSOL® - VSL RETAINED EARTH



DESIGN &
ENGINEERING
SUPPLY
INSTALLATION
MONITORING

VSoL® - DELIVERING HIGH-PERFORMANCE


Highway A8, Spain - 2005

Worldwide network

VSL operates through a worldwide network of 35 subsidiaries, supported by manufacturing facilities in Europe and Asia. The Group provides technical consultancy and services through its 4,100 employees, including more than 1,000 engineers and technicians.
It covers the full range of work from project planning (including development of preliminary designs and alternative design proposals) to specialised construction operations. In the field, VSL works mainly using its own workforce and equipment.

More than 50 years of engineering experience

VSL's specialist construction systems have been used throughout the world since 1956 and have earned an excellent reputation for quality and reliability. This has made VSL a recognised leader in specialist construction methods and associated engineering works.

Shaping a better life

For VSL, sustainable development means striking a balance in its business model between the economic profitability of its operations and their social and environmental impacts. This commitment is formalised into the VSL Sustainable Development programme, which focuses on safety, use of fewer scarce materials and less energy as well as reduced production of pollution and waste.

VSL – guided by a strong QSE culture

VSL's leading position in the industry is based on a rigorous and committed quality culture. Its Quality, Safety & Environment policy provides a strong focus for every service that is provided. Local teams ensure co-ordination of actions, encourage sharing of experience and promote best practices, with the aim of continuously improving performance. In VSL's culture, employees are vitally important to the competitiveness and prosperity of the company. VSL is committed to maintaining the highest levels of client satisfaction and safety for personnel.

The VSL Academy – a unique training facility for VSoL® wall construction techniques

Ensuring the highest levels of competence is a key focus. VSL applies the principles of


A strong QSE culture

continuous learning and training, together with the sharing of best practices throughout the network. Foremen, supervisors and site engineers benefit from centralised training at the VSL Academy, where they are taught best practice in all aspects of VSoL® wall construction.

VSoL® - one of VSL Group's leading brands

The VSoL® wall system is recognised as a revolutionary technique in the field of retained earth wall construction.
VSoL®, a registered trademark of the VSL Group, provides customised solutions adapted

CREATING SOLUT

CE SOLUTIONS FOR MORE THAN 30 YEARS

to the client's technical and architectural requirements. The specialist know-how of VSL's engineers provides the foundation for the success of the VSoL® wall system, which combines reliability with ease of construction.

VSoL® - a versatile solution for retaining walls

The VSoL® wall system is a cost-effective, high-performance retaining wall system that has proven its excellence in a wide variety of applications.
Since its development in the early 1980s, the VSoL® wall system has been used extensively worldwide to provide cost-effective and aesthetically appealing retaining wall solutions on a wide range of infrastructure projects. The VSoL® wall system combines concrete facings and soil reinforcement made from welded wire mesh or VStrips, VSL's polymeric strips, installed into compacted fill to form a coherent retained earth block which resists forces generated within and behind the wall.
The system is widely used for projects ranging from general grade-separation retaining walls to highway bridge abutments and mining structures. In addition to its high level of performance, the VSoL® wall system is very economical and is easy and rapid to install, with only three primary components. The use of factory-produced elements combined with speedy erection results in a high-quality wall finish that is achieved with cost savings of up to 50% compared to traditional wall systems.

Unlimited applications

The VSoL® wall system meets project requirements for projects in both the private and public engineering sectors. Owners, engineers and contractors worldwide make use of VSoL® for the construction of many types of structures, whether temporary or permanent, and various backfill soils and foundation conditions can be accommodated in the design. Straight, curved, tiered, superimposed or back-to-back walls can all be catered for in a wide variety of site conditions.
Urban, marine, mountainous and flood-prone sites can all be accommodated thanks to the design flexibility of the VSoL® wall system.

VSoL® - a comprehensive solution

VSL assists clients and their consultants at all stages of a project from feasibility studies to project completion. Preliminary designs, cost estimates and construction details as well as detailed designs, drawings and specifications are made available to assist clients in selecting the optimum solution for their projects.

The VSoL® wall system can be tailored to suit each customer's requirements and VSL's services range from the design and supply of the specialist materials right through to a complete contractual arrangement for the partial or full scope of wall installation. Services may include:

- Feasibility studies
- Design and detailing
- Precasting
- Installation and backfilling
- Monitoring
- Complete turnkey projects, from design to complete wall construction

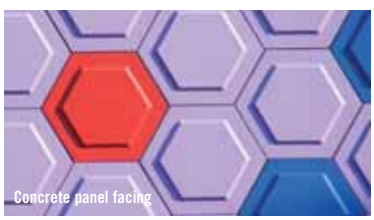
Mont Saint-Michel, France - 2012

TIONS TOGETHER

VSoL® - HOW IT WORKS

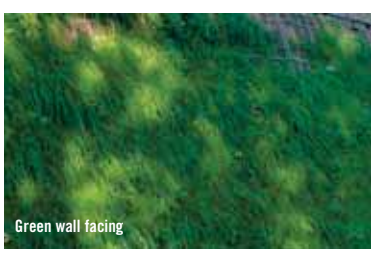
A VSoL® wall combines granular backfill material and reinforcement which can be either steel mesh or polymeric VStrips. These are installed behind facing panels, which are customised for the project. The combination of these three primary materials in the VSoL® system creates a durable and very stable retaining wall.

VSoL® wall with VStrip reinforcement



Concrete panel facing

Stone facing



Green wall facing

1. Facings

Facings are structural elements which retain and confine the backfill material and are tied to the reinforced fill by the mesh ladders or VStrips.

Different types of facings are available to suit project individual requirements:

- Concrete finishes of different shapes, textures and colours
- Steel mesh facings, which may be filled with rock for a natural stone finish
- Vegetated surfaces, incorporating geotextiles for containment and facing panels which retain the soil, root systems and irrigation needed to sustain the vegetation which will grow to cover the entire wall surface.

2. Reinforcement

The reinforcing elements are either steel 'ladders' or polymeric VStrips.

The reinforcement develops a high soil to reinforcement interaction and pull-out resistance, ensuring stability, excellent alignment and reliable performance. The reinforcing elements tie the facings into the soil mass and resist the horizontal soil forces generated both within and behind the wall.

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VSoL® wall with steel mesh reinforcement

Polymeric reinforcement

3. Reinforced fill

The reinforced fill material in a VSoL® wall is chosen to meet both system requirements and project specifications. Such requirements cover gradation, shear strength, permeability, pH and electrochemical properties.

VSoL® walls are typically built using granular material with less than 15% fines (< 80μm) and a maximum particle size of 150mm, although fills outside this specification can be assessed on a project-by-project basis.

VSoL® walls are often built using fill materials sourced on the site, making the wall an even more cost-efficient and environmentally friendly solution.

Simple and rapid installation

The simplicity of the installation method coupled with rapid reinforcement connections ensures cost-effective wall construction. VSoL® walls are easily constructed:

1. Casting of mass concrete levelling pads, generally measuring 300mm x 150mm and un-reinforced;
2. Erection and alignment of the first row of half-height and full-height facings;
3. Installation of joint and drainage materials;
4. Fill placement and compaction up to the level of the first layer of reinforcement in 300mm steps;
5. Installation of reinforcement and the connections to the facings;
6. Placing and compaction of additional layers of fill up to the top of the half-height facings;
7. Installation of the second row of facings;
8. Repetition of steps 3-7 until the full wall height is completed;
9. Installation of copings and crash barriers at the top of the wall to suit project requirements.

Depending on the wall geometry and site conditions, construction is normally undertaken using a four-man crew working with a small crane or truck-mounted crane and conventional earthmoving and compaction plant. Installation is generally carried out entirely from the rear of the wall, which permits ease of construction on restricted sites.

VSoL® wall construction can proceed rapidly, with productivity usually dictated by the schedule of fill delivery and placement. Wall erection rates vary depending on the project size, access and fill material delivery timetable.

VSoL® - ECONOMICAL, VERSATILE, AEST

CREATING SOLUT

STHETICALLY PLEASING

An economical wall solution

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

Low maintenance

The wall design is carried out in accordance with project specifications and can give a design life of up to 120 years. Concrete facings are very durable and require little maintenance, the steel reinforcement is designed to allow for the anticipated sacrificial loss over the wall's life and the polymeric strips are fully tested in a range of environments to provide long-term durability.

Highly versatile

VSoL® walls are extensively used to replace conventional retaining wall structures for many applications including roads and highways, railways, industrial and protective structures, transportation facilities, bridge abutments and many more.

Suitable for temporary use

VSoL® walls can be used as temporary structures for many different applications. Uses also include temporary grading of a project site to accommodate different construction phases. VSoL® walls can support very heavy loads at any stage of construction and can remain buried once work is complete or can be dismantled quickly and efficiently.

The advantages of VSoL® walls are numerous and include a very fast turnaround for design and construction, cost-efficiency, suitability for a large variety of applications and ease of dismantling, with all materials recyclable.

Seismic performance

VSoL® walls are strong, yet flexible enough to resist the high forces and movements arising from seismic activities. During an earthquake, the seismic forces are dissipated by friction between the reinforcement and the fill. Inherent ductility and resilience, coupled with the proven seismic performance of VSoL® walls, justify their high degree of adoption in seismically active regions.

Aesthetics without compromise

With a wide range of styles, facing shapes, sizes and finishes, the VSoL® wall can meet all architectural challenges. Facing finishes can be designed to blend easily with the environment or, where desired, to create a prominent artistic landmark.

Ideal for very poor ground conditions

VSoL® walls are internally stable reinforced soil structures and so are more accommodating to settlement than most other forms of wall construction. The use of flexible reinforcement connections and settlement-tolerant facing details means that VSoL® walls can be built on sites with poorer foundation soils than conventional walls, without affecting the structural integrity and performance of the finished structure.

Construction without disruption

VSoL® walls can be built entirely from behind the facing, which ensures that construction does not interfere with access, traffic or any obstacles in front of the wall.

TIONS TOGETHER

TWO OPTIONS FOR REINFORCING ELEME

VStrip: the VSL polymeric strip

In recent years, the VSoL® wall system has been developed to include the use of VStrips as reinforcement.
The reinforced VSoL® polymeric wall system uses VStrips or friction ties made from high-strength polyester yarns extruded into a durable polyethylene sheath which provides physical and chemical protection to the reinforcement.
The use of VStrips increases the versatility of the VSoL® wall system, as the polymeric friction ties extend the range of projects for which the system can provide an effective and economical solution.

Rolled-up polymeric strip reinforcement


Installation of friction ties to facings

Aggressive environment

One of the major advantages of using the VStrips is that the use of polymeric components ensures long-term durability of the structure in aggressive environments.

Simple installation

Vstrips come in rolls of 100m-150m and with a choice of strength capacities: 30kN, 50kN, 70kN and 100kN. The polymeric strip is unrolled in the field and passed through a connection at the facing panel, from where it forms a 'V' shape in the fill with two lengths extending to the back of the reinforced fill block. A light tensioning is then applied to the strip lengths to remove the slack and provide a constant tension throughout the wall. Fill is then placed on top of the reinforcement in layers of typically 300mm and then compacted.

Advantages

- Well suited solution for very aggressive environments
- Easy storage and site logistics
- Simple installation

Connection to concrete facings: an innovative and patented solution


Pull out capacity testing of VStrip connection

To ensure full load transfer between facings and fill reinforcement in the VSoL® Polymeric wall system, VSL developed an innovative solution to connect VStrip reinforcement to concrete facings. The VStrip connection is simply a U-shaped internal slot at the rear of the concrete facing, formed by a reusable void former during concreting which the VStrip is inserted through during installation.

The VStrip connection has been tested extensively by VSL to prove its efficiency and to optimize the associated panel reinforcement details. The VStrip connection does not require any additional cast-in items and rebar requirements for the connection are part of the overall reinforcement requirement for the facing. By adopting this approach, the VStrip connection provides the most economical and practical connection solution which is fully proven by testing and trials. The innovative VStrip connection concept has been patented by VSL.


Castings of VSoL facings with VStrip connection


VStrip connection

Advantages

- Very economical
- No connection components to install on site
- Rapid installation

CREATING SOLUT

MENTS

VSoL® steel mesh ladder: proven performance

The VSoL® steel system's reinforcing mesh ladders develop the greatest soil-to-reinforcement interaction and pull-out resistance of any reinforced retaining wall system.
VSoL® steel mesh ladders are composed of longitudinal and transverse wires welded together. The ladders are generally galvanised to enhance durability. Black mesh ladders can be used for applications involving temporary walls.
The transverse wires are welded to the longitudinal ones in a way which guarantees optimum load transfer.
The connection between the mesh ladder and the clevis in VSoL® wall facing is simple and very effective, facilitating rapid and economical installation.


Facing to mesh connection

Advantages

- Highest interaction between soil and reinforcement
- Minimum labour for installation
- Simple installation


Steel mesh ladder delivery to site

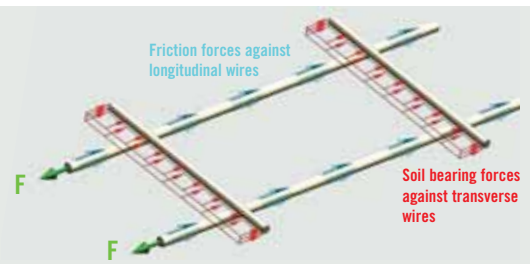
Simple installation

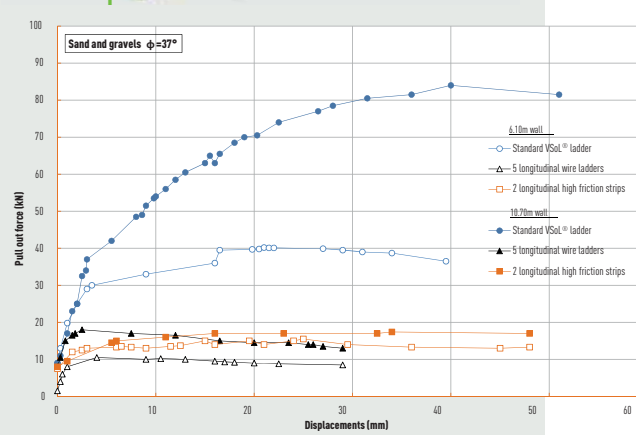
The simplicity and performance of the pinned connection is a key feature of the VSoL® steel system, enabling rapid installation on site. During installation, the mesh end-loops interlock with similar loops in the facing's clevis connectors and a full-strength joint is achieved using a connection pin. Slack between the clevis and mesh is removed using plastic wedges inserted between the concrete facing and the reinforcing ladder end-loop.

Interaction between soil and steel mesh ladder reinforcement

The performance of a VSoL® wall is based on the soil-reinforcement interaction mechanism, which is enhanced by the unique geometry of the mesh reinforcing ladder.
The interaction is achieved in two ways. The bearing action of the soil particles on the transverse wire develops a high resistance to extraction and ladder pull-out from the soil mass. This serves as a major advantage of the VSoL® steel system compared to other soil reinforcement techniques.
In the wall, the transverse wires are loaded by the soil and transmit the soil forces into the longitudinal wires, which are in tension.

Soil resistance against the transverse wires is the dominant interaction mechanism, compared to frictional forces against the longitudinal wires. Approximately 80% of the ladder's pull-out resistance is generated by bearing on the transverse wires compared with 20% from friction on the longitudinal wires.
Extensive testing has been carried out to compare VSoL® mesh ladders with other reinforcing systems. Tests have demonstrated that the use of three transverse wires generates a five-fold increase in the ultimate pull-out resistance, compared to reinforcement systems that use strip reinforcements.





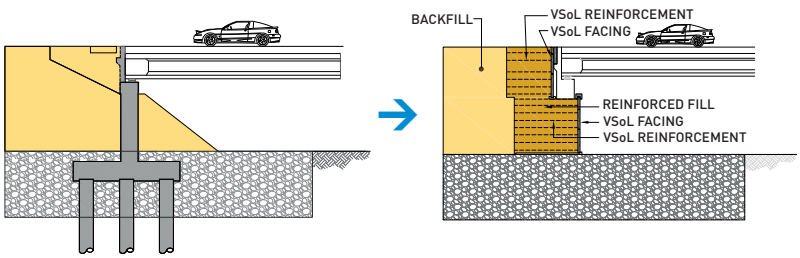
TIONS TOGETHER

A COST-EFFICIENT SOLUTION

VSoL® structures provide flexible solutions suitable for use on soils with low bearing capacity and can often avoid the need for deep foundations or ground treatment. VSoL® walls represent efficient alternatives to conventional structures.

Bridge abutments

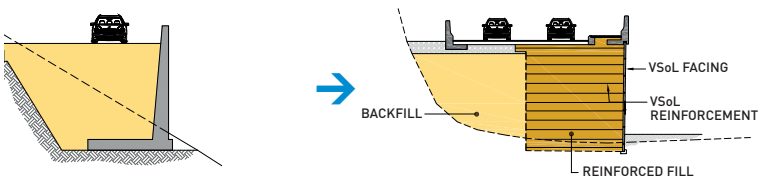
VSoL® walls frequently serve as bridge abutments which directly support the bank seat and the bridge deck where ground conditions permit. This avoids the need for deep foundations and costly abutment support structures. Where piled bridge supports are required, VSoL® walls can be incorporated into the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



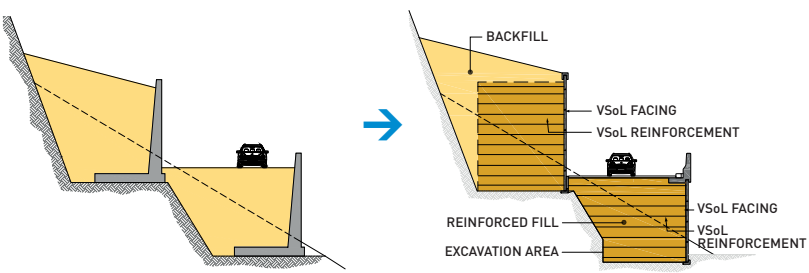
Savings 40 to 60%

Retaining walls

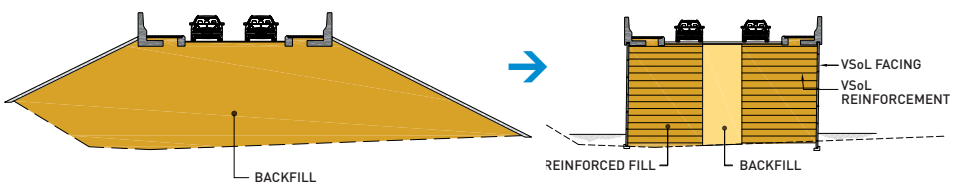
For projects such as highways and railways where the retaining walls need to bear heavy loads, the VSoL® wall solution can provide savings of up to 50% compared to the costs of conventional walls. This is particularly the case when the structure is founded on poor soil, which would otherwise require deep foundations or ground treatment to enable conventional construction methods to be used.



Savings 20 to 40%



Savings 20 to 50%



Savings up to 20%

CREATING SOLUT

A RELIABLE SOLUTION

VSoL® systems can effectively be used as risk mitigation and protection measures against natural disasters or industrial hazards. Such applications include protection against landslides, avalanches, floods, fire and blast and particularly earthquakes.

SEA WALL PROTECTION

Dibba Harbour & Beaches Phase 2 project, UAE - 2012

VSL was awarded a design and site assistance contract for VSoL® walls at a marine channel providing access for small boats to luxury villa plots. The length of the channel is 600m and it features 6m-high VSoL® walls on both sides of the canal.
The project's requirements were:

1. For the VSoL® panels to match the quay wall appearance;
2. To use VStrips to eliminate any problems arising from the sea water;
3. To accommodate designs for boat mooring platforms with stairs;
4. To accommodate the required drainage behind the wall.

EXCELLENT PERFORMANCE UNDER EXTREME SEISMIC CONDITIONS

VSoL® walls have very good resistance to the dynamic forces generated during major seismic events. US Federal Highway Administration guidelines state: "Due to their flexibility, MSE [mechanically stabilised earth] wall and slope structures are quite resistant to dynamic forces developed during a seismic event, as confirmed by the excellent performance in several recent earthquakes".
The 1989 California earthquake of magnitude 7.1 on the Richter scale and more recently the one in 2010 in Chile of magnitude 8.8 demonstrated very good examples of this performance. VSoL® walls up to 19m high were seen to perform very well under seismic loading. The good behavioural response of MSE and VSoL® structures during the earthquakes stems from their flexibility, ductility and composite performance. The VSoL® wall system's use of galvanised steel mesh ladders as reinforcement gives passive soil resistance on the transverse bars, which means that wall ductility is much better than for systems which use steel strips.

Chilean earthquake

The 2010 Chilean earthquake was at the time the sixth largest seismic event ever recorded by a seismograph and it proved the excellent behaviour of more than 28,500m² of VSoL® walls in the surrounding area. VSoL® walls and abutments were subjected to high ground accelerations and large deformations of the foundation soil, yet their geometry remained unchanged after the earthquake.

MINING APPLICATIONS

VSoL® structures are ideally suited to many industrial applications due to their capacity to withstand vibrations, impact, explosions, flooding and heavy loading.
They offer many advantages to the mining industry and are widely used to create temporary roads and elevated platforms to store materials. Benefits include speed and ease of construction, resilience, resistance, performance and the ability to be used in building high walls. VSoL® walls are also easy to remove, which can be an important factor as these types of structures are generally only for temporary use.

TEMPORARY WALLS TO SUPPORT VERY HEAVY LOADS

Flamanville nuclear EPR facility

VSoL® walls are particularly suitable for applications requiring the temporary support of heavy loads as used at the new EPR (European Pressurised Reactor) nuclear facility in Flamanville, France.
Construction of working platforms on the congested site and particular challenges with regard to time and space required the construction of a number of temporary retaining walls. Initially the walls were to be built using conventional prefabricated concrete methods. However VSL was awarded the contract for wall construction based on an alternative VSoL® wall solution which enables the tight programme to be met.
On this site, the world's largest and most powerful mobile hydraulic crane, the Liebherr LTM 11200 with a capacity of 1200t, has been operating on top of the VSoL® walls for the installation of critical EPR components.

A WIDE CHOICE OF FINISHES: SIZE, SHA

The VSoL® wall system's concrete facings can accommodate many shapes, patterns and textures. In addition, the concrete can be coloured to match the natural surroundings or any specific architectural requirements. Raised relief, sandblasted, exposed aggregate and conventional smooth facings represent just a few of the standard VSoL® facing finishes which are available. Other facing systems, such as full height facings, wire mesh and 'green' finishes are also available for both permanent and temporary structures.

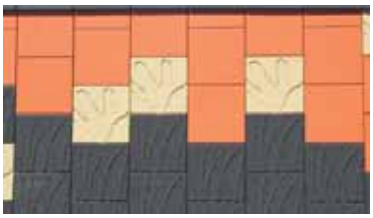
Artistic finishes

A wide variety of custom architectural finishes can be incorporated into the concrete facing through the use of form liners. Many kinds of striking repetitive motifs and designs can be created to enhance and give character to VSoL® wall structures and their surroundings. Mural patterns can easily be achieved on full-height facings, with a fully customised pattern on each facing allowing an original work of art to be created on every wall.

Large choice of facings

Three types of facings

Concrete facings



Precast concrete facings are the most common. Panels may incorporate special colours, textures or patterns to enhance the appearance of the structure.

Wire mesh facings

Structures with wire mesh facings are often employed to provide temporary support for roads and bridges, although many permanent walls have also been built in this way. The walls use a large mesh size and spacing, making the wire facing systems the fastest, easiest and most economical to install. Black mesh is typically used for temporary wall applications, while hot-dip galvanised steel mesh is preferred for permanent walls.

Green wall facings

Environmental and landscaping requirements have led engineers and architects to look for novel methods of constructing retaining walls and slopes. This has led to the addition of 'green' facings to the VSoL® wall system range to provide a very economical solution for vegetated steep slopes and walls.

CREATING SOLUT

HAPE, COLOUR

Shape

Square or rectangular concrete facings are most commonly used in the VSoL® wall system as they offer fabrication and construction benefits. However, many projects are built using hexagonal and T-shaped facings.
The standard facing sizes used are typically in the range of 1.5m x 1.5m to 2.5m x 2.5m.
Special facing sizes make it possible to create VSoL® walls of almost any geometry.

Full height facings

Full-height facings are available for special finishes or for artistic patterns. Walls with facings up to 14m high have already been built.


Full height facing

Different facing shapes available


T-shape


Hexagonal


Square


Cruciform


Rectangular

VSOL® - A WIDE VARIETY OF APPLICATI

The VSoL® wall system has revolutionised construction and can be applied to numerous types of retaining structures for various applications.

Highways and roads
Southern Expressway Muscat, Oman - 2010
(Record height wall of 65m)

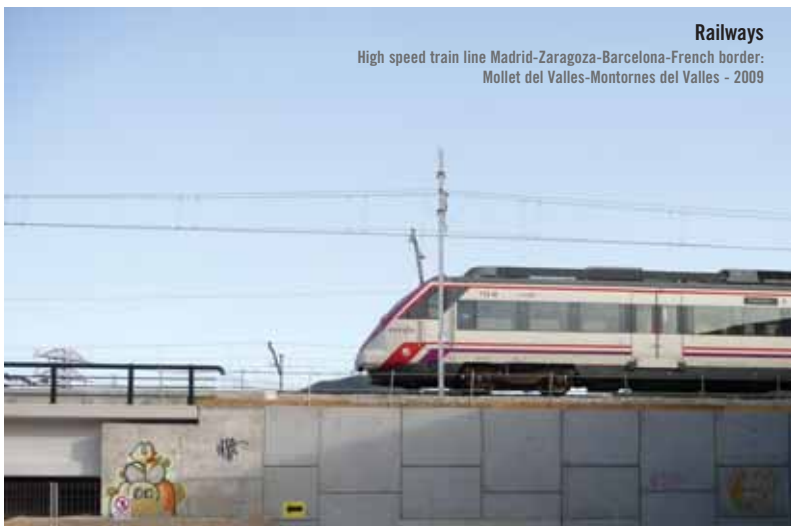
Temporary retaining structures
Temporary wall Paris, France - 2012

Bridge abutments
Carretera AS-112 Tramo Moreda Corigos, Spain - 2006

Public facilities
Coimbra pediatric hospital, Portugal - 2012

C R E A T I N G S O L U T

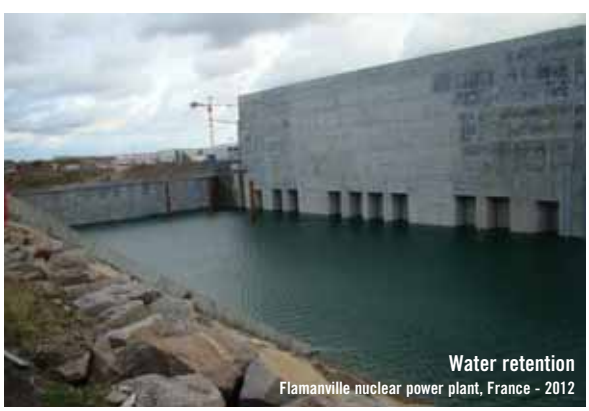
TIONS



Railways
High speed train line Madrid-Zaragoza-Barcelona-French border:
Mollet del Valles-Montornes del Valles - 2009

Green walls
Mont Saint-Michel, France - 2012

Industrial and protective structures
RT Sulfuros, Chile - 2009



Water retention
Flamanville nuclear power plant, France - 2012

Arch structures
Peninsula link Melbourne, Australia - 2012

T I O N S T O G E T H E R

TESTING AND DURABILITY

The VSoL® wall system has been continuously improved since its development in California in the 1980s.

VSoL® Steel mesh ladder

Optimised design

A research programme was carried out in 1997 to increase understanding of the performance of VSoL® soil reinforcing mesh ladders. VSL undertook the work in conjunction with the French Laboratoire Central des Ponts et Chaussées (L.C.P.C.) and the Service d'Etudes Techniques des Routes et Autoroutes (S.E.T.R.A.). Accelerated corrosion testing was carried out as part of the detailed study of the durability of both black and galvanised VSoL® mesh ladders. The tests involved the immersion of test specimens in saline liquids to simulate conditions that could causes corrosion of the mesh. Complementary tests were also undertaken using acid solutions to extend the results of the study.

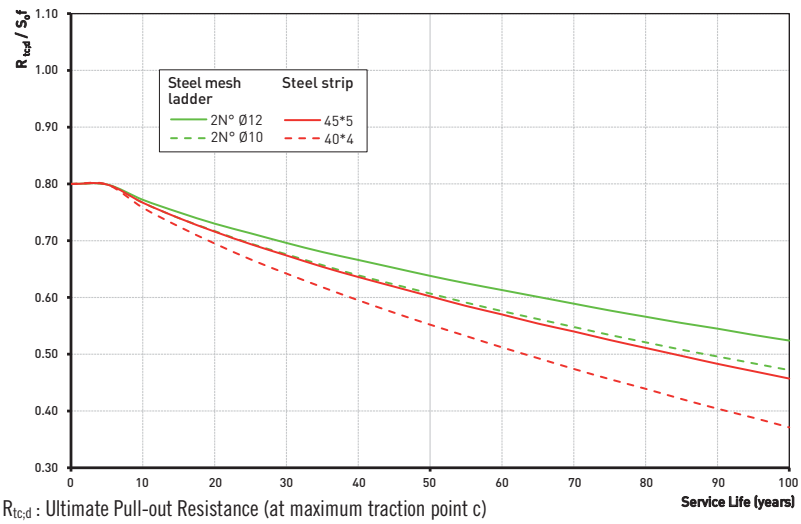
The tests confirmed that corrosion occurs uniformly around the circular cross-section of the steel wire of the VSoL® wall mesh ladder. This is in contrast to rectangular steel strips, where the corrosion develops more intensely on the upper surface than on the underside of the strip.

Performance of the welded joints

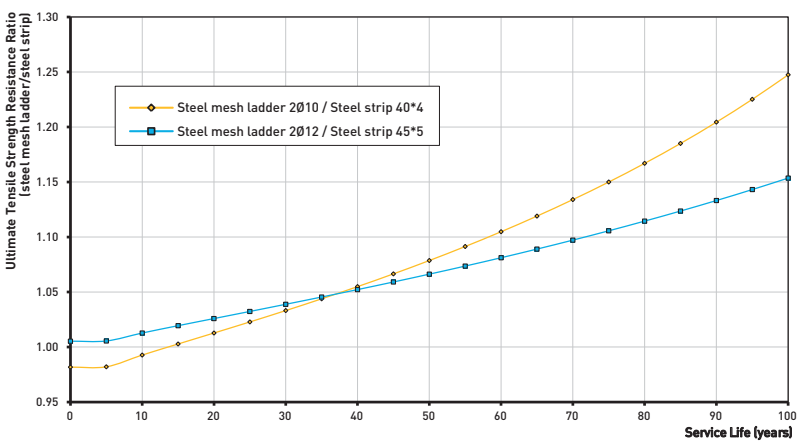
Strength tests were carried out on samples of steel mesh ladder after they had experienced prolonged exposure to the aggressive test environments. The tests proved that the welds of the steel mesh ladder had suffered only limited corrosion in relation to the longitudinal and transverse wire sections. It was proven that the welds are no weaker than the ladder's normal circular steel wire sections after corrosion has occurred.

Accelerated corrosion tests on samples of black steel wire that were dipped in acid for a period representing a service life of 100 years showed a retained strength as expected by the French design code. In addition, the effects on the welded sections were similar to those of the normal black wire sections. Hence, the sacrificial loss as specified in international design standards can be applied to the entire VSoL® steel mesh ladder and no additional corrosion allowance is required at the welds.

The sizing of VSoL® steel mesh ladders takes into account the potential for sacrificial loss of steel over the design life of the structure in accordance with all international design codes applicable to VSoL® wall applications.



$R_{tc;d}$: Ultimate Pull-out Resistance (at maximum traction point c)
S_0 : Initial Steel Cross of a Longitudinal Wire
f_r : Ultimate Tensile Strength



VSoL® VStrip

VSoL® VStrips are made from polyester yarn, extruded inside a polyethylene shell which is designed to enhance the friction with the surrounding soil and ensure high durability of the strip. It is a non-metallic component and as such is not subject to corrosion, making this component very durable.

Conformity with design codes

The retained strength and steel loss of the VSoL® mesh ladder specimens tested for VSoL® wall applications was found to be in accordance with the anticipated sacrificial loss as per international design standards.

VSoL® concrete facings

Concrete facings are designed in accordance with project specifications and local design standards.
Conforming to the relevant codes for the facing panel design gives assurance of wall facing durability.

Backfill testing

Reinforced fill is placed and compacted to reach a maximum density as per the project specification. Density testing can be used to verify the compacted fill density in every fill layer.

QUALITY ASSURANCE

All VSoL® wall components are tested and checked in accordance with VSL's quality assurance programmes. The use of standard components designed and manufactured in accordance with national standards minimises the need for project-specific testing, while offering the security of a tried and tested system.

Clevis connector pull-out test

VSoL® steel mesh ladder in-situ pull-out test

Steel mesh ladder end-loop capacity test

VSoL® steel mesh ladder laboratory pull-out test

Testing of VStrip connections

Proven system and components

Key features of the steel system are the pinned connection to the facings and the ability of the reinforcing mesh ladders to develop high pull-out resistance in the soil at low strains. Extensive testing of the mesh ladders with a variety of reinforced fills has clearly demonstrated the superior interaction of VSoL® wall mesh with typical project fill.

CONTRIBUTING TO SUSTAINABLE SOLUTI

Material savings
Material savings in concrete and steel in comparison to traditional wall systems can range from 20% to 60%, depending on the wall height and the loads applied. VSoL® walls take advantage of the soil strength and weight behind the wall and make them contribute to the overall structural stability.

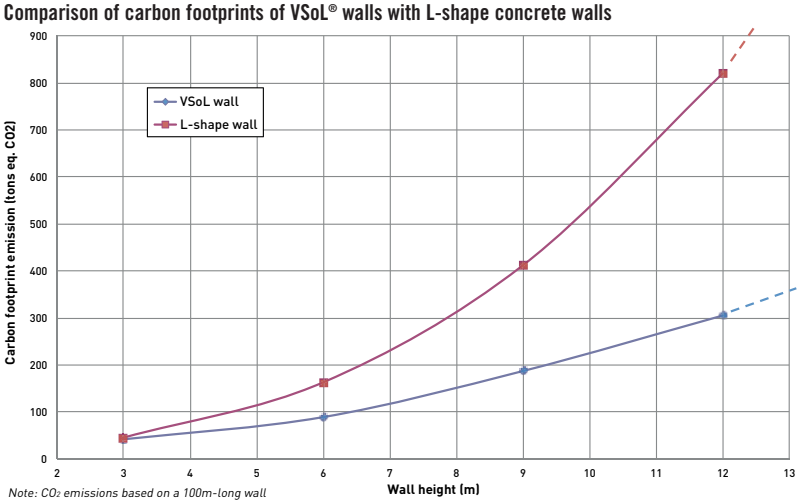
Very resilient structures
VSoL® walls have excellent resistance to severe earthquake loading, with many VSoL® walls remaining standing after major seismic events when adjacent conventional structures have collapsed.

Becoming part of the landscape
VSoL® walls can accommodate a wide variety of finishes, with concrete, stone and vegetated finishes available to match the surrounding environment and thus enhance the local landscape.

Ease to dismantle and 100% recyclable
VSoL® walls are easy to build and similarly easy to dismantle. They do not produce large amounts of unusable waste materials. The fill materials can be reused directly or in other walls, while facing elements can be reused or recycled into aggregate for walls, road-base or other construction materials.

Up to 60% reduction of CO_2 footprint, and above
The combination of thin facings and site-won backfill as primary structural elements makes VSoL® walls very efficient in terms of material use. This dramatically reduces the need for concrete and rebar and therefore reduces the overall CO_2 footprint of the construction project.

Comparison of carbon footprints of VSoL® walls with L-shape concrete walls



Note: CO_2 emissions based on a 100m-long wall

Carbon footprint values are for a 100m-long wall compared to a conventional reinforced concrete cantilever wall. CO_2 emissions have been calculated with CarbonEco® developed by VSL.
- Loading on wall: 10kN/m² (Live Loads) = 1T/m²
- VSoL® wall reinforced fill material: all imported from 20km
- L-shape with fill material:
  - walls below 6m height: all local (1km)
  - walls above (and including) 6m height: 50% local (1km) and 50% imported from 20km

HIGH QUALITY AND SAFETY RIGHT FROM THE START

22,000m² and zero accidents on the Anderson Road Project, Hong Kong
VSL built 10 VSoL® Retained Earth walls totalling 22,000m² for a site formation development at Anderson Road, Kowloon, to help create level ground for future high-rise residential housing. The VSoL® walls used 4m² rectangular masonry-finish facings and featured sections between 25m and 36m high. The VSL Hong Kong site team had a strong focus on QSE matters and this was rewarded by a zero accident rate, recognised by both monthly and quarterly safety awards from the main contractor.

CREATING SOLUT

TIONS

Copy nature

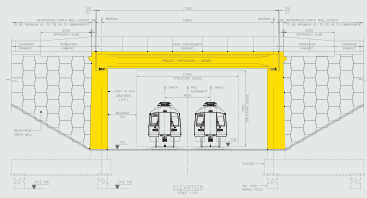
VSoL® - blending with the natural surroundings

The visual design of the facing of a new French by-pass mimics the local geology, including the natural rock strata. The facings were made using five different carved rock moulds.

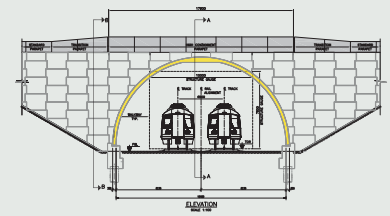
The northern end of the new Thonon-les-Bains Bypass brought local environmental challenges. It was essential to preserve the local Drance ecosystem while ensuring the overall stability of the slopes above the river. The designer's solution uses retained earth walls built with the VSoL® system. This met both aims, providing the necessary support and minimising the impact on the environment.

The project consisted of a cascade of four VSoL® retaining walls faced with 9,250m² of concrete facings.

CASE STUDY: VSL-BEBO® AN EFFICIENT ALTERNATIVE TO SMALL TO MEDIUM SPAN REINFORCED CONCRETE BRIDGES



Original design



Alternative VSL-BEBO® arch design

This carbon footprint compares a conventional bridge solution with a solution combining VSL-BEBO® precast arches and VSoL® reinforced soil wall for an overpass bridge on the Etihad Rail project in Abu Dhabi, UAE.

The alternative design consists in replacing the reinforced concrete footings, the reinforced concrete abutment walls and the prestressed precast concrete beams by VSL-BEBO® reinforced concrete arches (with the corresponding foundations and footings) and VSoL® reinforced earth walls.

The VSL-BEBO® + VSoL® solution presents a reduction of nearly **74% of CO_2 emissions.** The VSL-BEBO® arch solution, combined with the VSoL® soil wall system, provides a sustainable and energy efficient alternative to the original bridge design.

Become nature

VSoL® - natural vegetated 'green' walls at Mont St-Michel

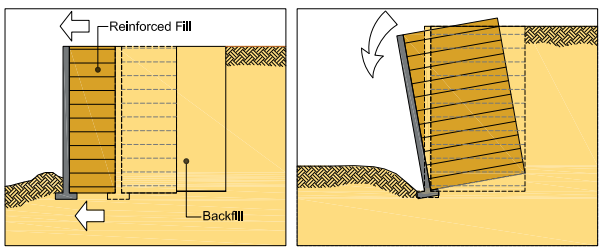
The VSoL® wall system was chosen for the construction of 'green' sea walls as part of the rehabilitation of the access area at Mont-Saint Michel, the UNESCO world heritage site in France. Access for the new car park had to be provided through an existing swamp. Building the new site's car park on the swampy ground required construction of various green slopes to ensure perfect integration with the surroundings.

DESIGN PRINCIPLES

A VSoL® wall is designed as a reinforced mass large enough to resist loads from outside the wall and with enough reinforcement layers of sufficient strength to keep the reinforced soil mass together.

External stability

The VSoL® reinforced soil block behaves like a large gravity wall. The external stability is checked with respect to sliding on the base of the wall, for overturning, bearing failure, foundation settlement and overall stability.

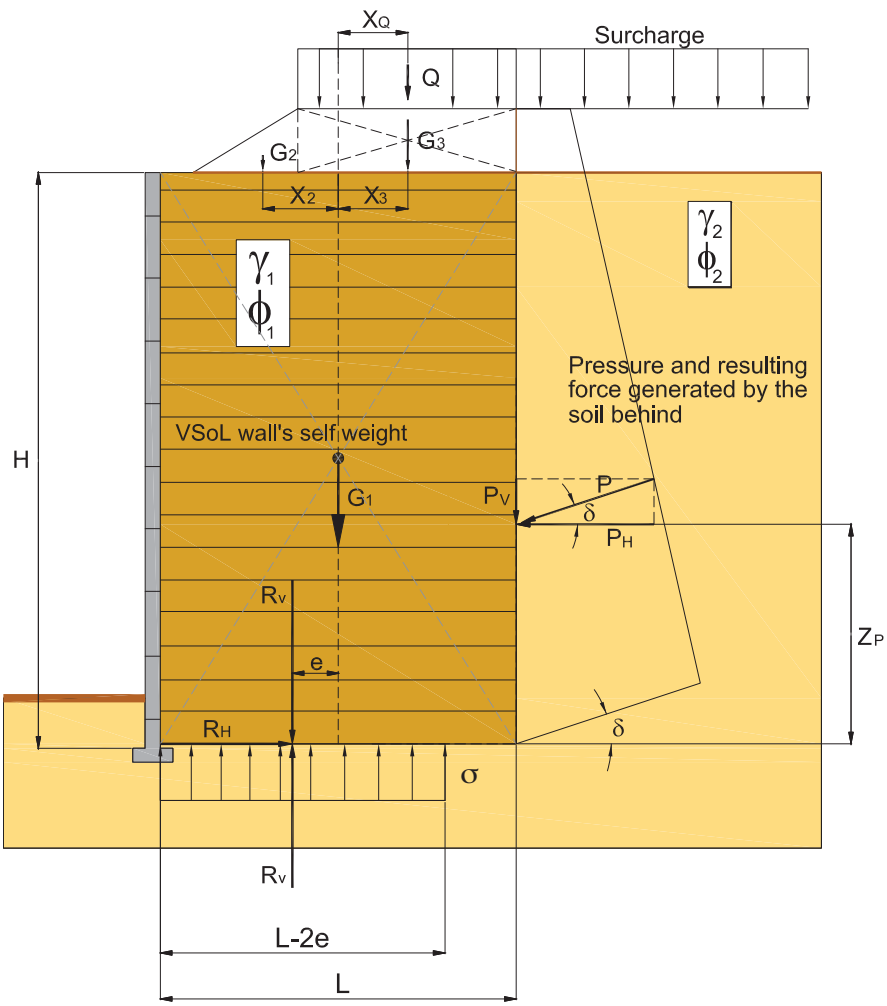


Sliding check

Bearing capacity and overturning check

Design mechanism

The VSoL® block is subjected to external forces, which are modelled in the design.



Resultant forces taking account of all forces over the base of the wall:

$R_H = P_H$

$R_V = \sum G_1 + Q + P_V$

Resultant moment over the base of the wall:

$M = \sum G_1 X_1 - Q X_Q + P_H Z_p + P_V L/2$

Resulting eccentricity of the forces over the base of the wall:

$e = M / R_V$

Resulting pressure on supporting ground:

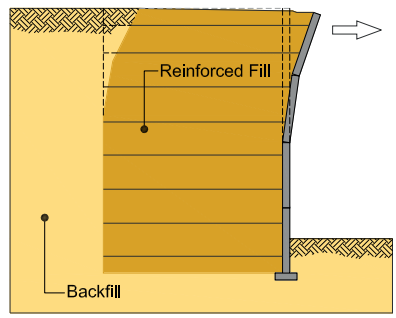
$\sigma = R_V / (L - 2e)$

CREATING SOLUT

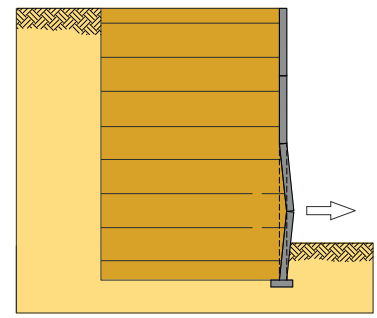
The facing is secured with a full-strength connection to the soil reinforcement in order to keep the facing units stable and all components properly connected to ensure wall stability.

Internal stability

This refers to the strength and stability of the reinforced fill block. At each reinforcement layer, the facing strength, reinforcement strength and reinforcement's pull-out strength are checked to withstand the applied design loads and to ensure that the reinforcement is fully anchored in the soil mass.



Pull-out capacity check

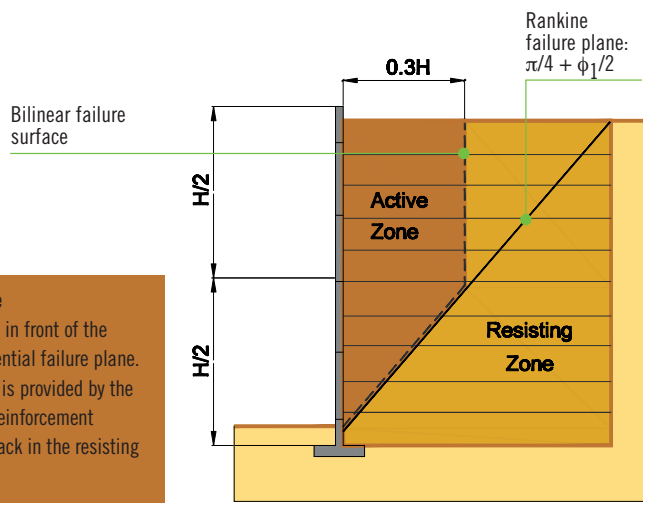


Tensile capacity check

Design mechanism

From a mechanical standpoint, the block may be divided into two distinct zones:

- the active zone
- the passive zone



Active zone
This zone is in front of the critical potential failure plane. Its stability is provided by the horizontal reinforcement anchored back in the resisting zone.

Resisting zone
This zone lies behind the critical potential failure plane and is a stable reinforced mass, which resists the destabilising tension forces developed in the reinforcement by the active zone. The resisting zone provides anchorage for the reinforcement by the mechanism of the soil/reinforcement bond. The tensile load in the reinforcement over the length which is in the resisting zone is not constant. It reduces towards the inner end of the reinforcement (located opposite from the facing) as load is shed into the soil. At that inner end of the reinforcement in the resisting zone, the tensile load in the reinforcement is zero.

Built to standards
VSL has developed efficient software which automates the design of VSoL® walls, regardless of project geometry.
All VSoL® wall projects are designed and built in accordance with the latest standards, including:
BS 8006: UK code of practice for strengthened reinforced soils and other fills
AASHTO: USA – specifications for highway bridges
GEO: Hong Kong–GeoGuide 6
AS 4678/RTA R57: Australia
EUROCODE: Europe – EC7
NF P94-270: France – French national standard

VSL'S KNOW HOW


Circunvalación Spilimbergo Córdoba, Argentina - 2010


Châtellerault, France - 2012


Hamilton Road, Australia - 2007


Airport interexchange, Oman - 2006


Access to the port of Ferrol, Spain - 2008

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Collahuasi Mine, Chile - 2004


An Suong, Vietnam - 2005


Thonon-les-Bains, France - 2008

East Link Project,
Australia - 2005


Dawson Mine,
Australia - 2007


Marao Highway,
Portugal - 2012

MORE REFERENCES


Avenida Circunvalar bridge access, Colombia - 2003


Castle Peak Road, Hong Kong - 2004


Avenida Pontos Barrassa, Spain - 2010


Shatin Heights, Hong Kong - 2006


Mandurah Entrance Road, Australia - 2011


Kralupy wanany, Czech Republic - 2002


Variante de Canjayar, Spain - 2006

CREATING SOLUT

Thonon-les-Bains, France - 2008

Déviation de Lure, France - 2008

Geelong Bypass, Austrlia - 2011

South East Transit, Australia - 1999

Marga-Marga project, Chile - 2001

TIONS TOGETHER

VSL'S RELATED ACTIVITIES

SEGMENTAL ARCH CONSTRUCTION – A SUSTAINABLE AND ENERGY EFFICIENT ALTERNATIVE


Penrith Lakes, Australia - 1995

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

The arches are built by assembling precast segments in a staggered symmetrical pattern. The construction of a precast arch structure is simple, rapid and predictable, requiring conventional equipment and just a small crew. VSoL® walls can be combined with VSL-BEBO® Arch solutions to create cost-effective low-maintenance aesthetically pleasing bridges as well as drainage culverts through walls.

VSL provides design, casting and installation services for the arch projects, using elliptical, circular or flat arch profiles to suit project requirements.

Arch applications include overpasses, bridges, tunnels, culverts and underpasses as well as other structures.

VSL ENGINEERING

Each project presents unique challenges and, in recognition of this, members of VSL's technical staff work with contractors, owners and engineers to evaluate projects and determine optimum solutions. VSL engineers have a cultural and professional responsibility to design safe, economical and buildable structures that meet the current and future needs of their owners and the public. Looking for savings and recycling opportunities, this issue has become an integral part of VSL Technical Centres' day-to-day activities.

BRIDGE CONSTRUCTION

VSL provides a full range of technical and construction services for bridge construction, including design evaluation, temporary works design, permanent works design and construction engineering, precasting management and bridge construction.

VSL has contributed to some of the most prestigious and complex structures around the world, ranging from conventional precast beam crossings to large span cable-stayed bridges.

As a specialist partner for bridge construction, VSL can bring to the project team a wealth of experience. This experience has been gained from erecting more than 100,000 precast bridge deck elements (with a surface area of almost five million square metres), constructing multiple in-situ bridges using VSL form-travellers and incremental launching methods and also being involved in the construction of over 150 cable-stayed bridges worldwide.


Hunter Expressway, Australia - 2012

CREATING SOLUTIONS TOGETHER

MONITORING

VSL offers instrumentation and monitoring services for all structures including VSoL® walls.

Monitoring of VSoL® walls can be carried out to provide information on the magnitude and distribution of reinforcement tension, soil pressures, vertical and lateral movements and foundation soil settlements. Instrumentation is installed during construction and monitoring equipment is set up to record and send data automatically to the client's office for analysis.

GROUND ANCHOR SYSTEMS

VSL has extensive experience in the supply and installation of ground anchors.

VSL Ground Anchor systems are in use around the world, securing famous structures, large dams and retaining walls, underpasses, underground structures, wind turbine towers and much more.

VSL Ground Anchors may be installed as temporary or permanent solutions in combination with VSoL® walls to provide a complete wall and slope stability solution on a project.

Centenary Link, Australia - 2006

GROUND ENGINEERING

- Ground anchors
- VSoL® walls
- D-walls & Piles
- Ground improvement
- Ground investigation

CONSTRUCTION

- Bridges
- Buildings
- Slab on grade
- Nuclear Containments
- Offshore structures
- LNG & LPG containments
- Heavy lifting
- Formwork & Equipment

REPAIR, STRENGTHENING & PRESERVATION

- Structural diagnostics & Monitoring
- Repair & Strengthening
- Infrastructure Preservation
- Infrastructure Protection

SYSTEMS & TECHNOLOGIES

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

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