VSL AND VIBRATION CONTROL

VSL and vibration control
VSL started working with vibration control technologies some 15 years ago to develop solutions to the problems caused by stay cable vibrations. Backed by the strength of that experience and with many successfully-completed projects around the world, VSL can offer today’s clients an extensive menu of tailor-made solutions for buildings and bridges that require efficient damping solutions.

VSL – guided by a strong QSE culture
VSL’s leading position is based on a rigorous and committed quality culture. The QSE (Quality, Safety, Environment) policy represents a major focus for every service provided. Local teams ensure co-ordination of actions, encourage sharing of experience and promote best practice, 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 personnel safety.

Changing the way we do business
For VSL, sustainable development means striking a balance in its development model between the economic profitability of its businesses and their social and environmental impacts. That commitment is formalised into the VSL Sustainable Development program which focuses on safety, use of fewer scarce materials and less energy and production of less pollution and waste.

A pioneer in the post-tensioning industry
VSL has been recognised since 1956 as the leader in the field of post-tensioning works and related activities. The company works as a specialist contractor through a network of local subsidiaries and experts, offering a comprehensive range of professional services and solutions to suit every project’s needs.

VSL products and services provide optimal solutions and ensure the best value for every project and customer.

Innovation at the service of VSL’s clients
Teams of skilled and dedicated professionals with the support of a strong research and development ensure that VSL brings innovation to each project. The extensive range of services includes feasibility studies, structural design assistance, contractor consulting and field installation, all aimed at finding the best fully-customised solutions for every project.
The detrimental effects of vibration

Vibrations not only generate discomfort for the users of a structure and the people but can also be very detrimental to structural components, as they induce fatigue effects in the members. In extreme cases, vibrations can lead to failure of these components, either as a result of high energy events such as earthquakes or from more commonly-encountered phenomena such as wind.

It is essential to mitigate such vibration phenomena as much as possible in order to protect the structure.

The VSL VE damper solution

VSL offers a wide range of damping solutions based on the use of the VSL VE damper. Solutions depend on the vibration frequency and the structure’s mass, see table.

The VSL VE damper features the unique properties of super high damping rubber, which instantly converts vibration energy into heat energy through shear deformation. Building vibrations resulting from wind forces, traffic, human activities and even severe earthquakes are effectively controlled by VSL VE dampers.
THE VSL VE DAMPER SYSTEM
A unique material with exceptional properties

**Exceptional energy absorption**
The VSL VE damper dissipates movement energy through the deformation of a special material - VE High Damping Rubber (HDR). The rubber is inserted inside the key element of the VSL VE Damper, the HDR VE pads.

**Extreme adhesion**
The joint between the rubber and the steel plate is obtained by a vulcanisation process that creates an extremely robust bond between the two materials. When subjected to shear testing to failure, the breaking surface remains located inside the rubber material.

**Efficient vibration reduction** by adding dampers with regard to wind loading and seismic loading

Acceleration

Displacement
High capacity to deform
Thanks to its extraordinary ‘deformability’, the material can withstand very severe
dynamic movements without damage, making the system extremely durable.

Long-term durability
Ageing tests prove a life expectancy greater than
60 years without any deterioration in mechanical
c characteristics.

Not a structural device
for gravity loads
The VSL VE damper only works in shear to dissipate energy when the structure is subject to de-
formation due to vibrations. Whether taken into account as part of the structural design leading to optimisation of the structure member size or simply to enhance the serviceability of that structure, its safety and comfort, it does not withstand the permanent loadings, but instead works only to mitigate the transient loadings. Hence, its possible accidental destruction by fire does not compromise the direct stability and safety of the structure. In addition, because of its simplicity and easy access, the dampers can then be replaced easily to reinstate the full damping system after the fire. Optionally, the damper units can be protected by fire boards providing the desired fire-rating, similar to protection that could be provided to any structural steel member.
The flash point of the rubber material is at 200°C and the ignition point is at 360°C.

Other advantages
- Easy installation and replacement if necessary, such as for repair after a fire
- Cost effective
- Low maintenance
- Low dependency on temperature and frequency
DESIGNING WITH THE VSL VE DAMPER

How it works

The mathematical model of the energy absorption
The VSL VE damper works in shear only and dissipates energy when deformed.
The energy absorbed is a function of the hysteresis loop and parameters of VSL VE damper that are derived from cyclic shear testing.
The hysteresis loop of VSL VE damper complies with a modified bi-linear model, which enables engineers to perform accurate analysis and calculations.

Choice of shapes
VSL VE dampers are available in different shapes and sizes to suit their application and location.

Effective for all vibration modes
The behaviour of the VSL VE damper can be construed as a combination of spring, friction and viscosity. Therefore, the VSL VE damper is independent of the vibration mode and of the amplitude. The curve results extracted from full-scale tests, illustrate this behaviour. Extensive in situ, full-scale and laboratory tests have been carried out to assess the VSL VE damper’s performance.

Hysteresis loop of VSL VE damper

\[
W \cdot \text{Strain Energy}
\]
\[
\Delta W \cdot \text{Absorption Energy}
\]
\[
K_{eq} \cdot \text{Equivalent Stiffness}
\]
\[
H_{eq} \cdot \text{Equivalent Damping Coefficient}
\]
\[
= \left(\frac{1}{4\pi}\right) \times \left(\frac{\Delta W}{W}\right)
\]
Comparison between a base isolation system and a vibration control system using the VSL VE damper.

Seismic-resistant traditional design (no damping system)
Vibrations are resisted solely by the structure. Structures are, therefore, generally quite stiff. Forces generated by the vibrations are amplified and are entirely resisted by the structural members.

Base isolation system
The structure is designed and built over large bearings that take its overall weight. The bearings also serve to isolate the building from the direct impact of the vibrations, thus mitigating their effects on the structure. However, such a system requires large substructures and bearings.

Vibration control - energy dissipation using VSL VE dampers
The VSL VE dampers are located by the designer at the points in the structure where the largest displacements between members are expected. The amplitude of the movements depends on the structure's stiffness. When the structure is subject to vibrations, part of the energy is dissipated by the damping system, which mitigates the vibrations at every point where the dampers are activated.

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Base Isolation System</th>
<th>Vibration Control System</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GROUND CONDITION</strong></td>
<td>Difficult to apply on soft ground or easily liquefied ground</td>
<td>NO LIMITATION</td>
</tr>
<tr>
<td><strong>SITE CONDITION</strong></td>
<td>Necessary to take space around the building.</td>
<td>NO LIMITATION</td>
</tr>
<tr>
<td><strong>BUILDING HEIGHT</strong></td>
<td>Not economical to apply to thin and high building.</td>
<td>NO LIMITATION</td>
</tr>
<tr>
<td><strong>FREEDOM of DESIGN</strong></td>
<td>Necessary to use flexible piping and wiring.</td>
<td>NO LIMITATION</td>
</tr>
<tr>
<td><strong>WIND-INDUCED VIBRATION</strong></td>
<td>NOT EFFECTIVE (even for daily wind-induced vibration)</td>
<td>EFFECTIVE</td>
</tr>
<tr>
<td><strong>SMALL or MEDIUM SCALE EARTHQUAKE</strong></td>
<td>May not function even during a medium-scale earthquake.</td>
<td>EFFECTIVE</td>
</tr>
<tr>
<td><strong>LARGE-SCALE EARTHQUAKE</strong></td>
<td>As the vibrations of the building are gradual, furniture are not displaced nor collapsing. The building operation can continue normally after an earthquake.</td>
<td>Mitigate vibrations and maintain the functionalities of the building.</td>
</tr>
<tr>
<td><strong>AFTERSHOCK</strong></td>
<td>Cracks or disruptions that might appear in the ground below the building after a major shock may jeopardize the effectiveness of the system.</td>
<td>EFFECTIVE</td>
</tr>
<tr>
<td><strong>EXCEPTIONAL EARTHQUAKE</strong></td>
<td>Effectiveness of the system is uncertain in the case of an exceptional earthquake beyond the design assumptions.</td>
<td>Mitigate some vibrations</td>
</tr>
<tr>
<td><strong>WEATHER CONDITIONS</strong></td>
<td>In the event of flooding, the system requires checking as it is generally located in the basement of the structure and is therefore exposed to flooding.</td>
<td>The system is normally not located in floodable areas</td>
</tr>
<tr>
<td><strong>MAINTENANCE</strong></td>
<td>Must be maintained periodically.</td>
<td>Limited maintenance required</td>
</tr>
<tr>
<td><strong>OVERALL COSTS</strong></td>
<td>The system requires the substructure of the building to be designed around it, driving the loads to concentrated areas where the bearings are located. Additionally, it requires periodic maintenance. Overall, the cost of that system is substantial.</td>
<td>The initial investment is substantially lower, as well as the long term costs due to the minimum maintenance required for that system.</td>
</tr>
</tbody>
</table>
Applications in buildings
VSL VE dampers are located where the structure is most subject to deformation. Under vibration conditions leading to deformations of the structure, the VSL VE dampers are subject to shear and in turn dissipate the energy of the vibrations, mitigating the structure’s movements.

Wall and column type dampers
VSL VE dampers are integrated into prefabricated steel panels that are installed directly in the structure during construction. Optimisation at the design stage can keep the size and weight of these steel elements to a minimum, allowing the use of concrete wherever possible.
Brace type damper
For steel structures, VSL VE dampers are integrated into larger triangular beams, which are designed not to carry structural forces but are located where the structure is most subject to deformation. When the structure is subject to vibrations, these beams deform and introduce shear into the VSL VE dampers, which then dissipate the energy.

Retrofitting
VSL VE dampers can be utilised to retrofit existing structures. Assistance is available for designers through computer tools, which allow modelling of a structure and design of a damping system that is capable of sharing forces between the structure itself and the damping system.

Housing
In earthquake areas, VSL VE dampers are installed in prefabricated panels that can be integrated directly into the structure during construction.
OTHER APPLICATIONS

VSL VE dampers can potentially be installed anywhere where vibrations are present and need to be mitigated. Below are some applications that have already been implemented, although many other configurations could be imagined. VSL VE dampers have been installed in many structures and have proven their efficiency and cost effectiveness both at the installation stage and during operation and maintenance.

Bridges – Dampers for stay cables and bridge deck girders
VSL VE dampers are used extensively on cable-stayed bridges where vibration phenomena can be severe, requiring effective means of damping.

Retrofitting on bridges
In this case, main girder beams have been equipped with VE dampers reacting against a fixed point below mounted on columns. The VE dampers are activated during vertical vibrations into the beams, vibrations that are thus mitigated by the action of the dampers.

Marine applications
Wave-induced vibration is a well known phenomenon and can be very uncomfortable to the public. In this case, VSL VE dampers have been installed between the vertical posts and the floating deck. When this one is subject to vertical movements due to wave effects, the dampers are activated in shear and in turn reduce these vibrations.
The VSL VE damper: an effective means of increasing safety, reliability and redundancy in structures

The VSL VE damper works very effectively in dissipating energy due to vibrations, including those caused by external sources such as pedestrians walking on floors, cars circulating on bridges, by wind or earthquakes. Whether taken into account as part of the structural design leading to optimisation of the structure member size or simply to enhance the serviceability of that structure, its safety and comfort, it does not withstand the permanent loadings, but instead works only to mitigate the transient loadings.

As a consequence, engineers can design structures with reduced element sizes, which in turn reduce the forces induced by the vibrations. Ultimately, iterations achieve an optimised design for the structures and the most effective use of the materials required for construction. A further benefit is that the reductions in total weight of the superstructure, base shear and over-turning moments mean that the foundations can also be reduced.

Overall, the use of VSL VE dampers results in the whole structure from the foundations to the top being lighter than with traditional methods, while providing greater ductility and resilience to control the vibrations. All these benefits result in cost savings for the owner. In addition, VSL VE dampers require only limited maintenance because of their simplicity and very high durability. All this combines to make the VSL VE damper a very eco-friendly solution, which limits the carbon footprint of the overall structure.
VSL LOCATIONS

Headquarters
VSL International Ltd.
Sägestrasse 76
CH-3098 Könüz
Switzerland
Phone: +41 58 456 30 00
info@vsl.com

Africa

EGYPT
VSL Egypt
CAIRO
Phone: +20 2 344 19 00

SOUTH AFRICA
VSL Construction Solutions (Pty) Ltd
JOHANNESBURG
Phone: +010 492 1811

TUNISIA
VSL Tunisie
TUNIS
Phone: +216 70 72 84 73

Europe

AUSTRIA
Grund- Pfahl- und Sonderbau GmbH
HIMBERG
Phone: +43 2235 87 777

CZECH REPUBLIC
VSL Systems CZ s.r.o
PRAGUE
Phone: +420 2 51 90 36 80

FRANCE
VSL France S.A. (Bouygues TPRF)
LABÈGE
Phone: +33 5 33 65 96 59

GERMANY
VSL Systems GmbH
BERLIN
Phone: +49 58 456 30 30

NETHERLANDS
Heijnman Gevel b.v
Span en Verlatingsingtechnieken
ROSMALEN
Phone: +31 73 543 6611

NORWAY
Sparremering Norge AS
RUD
Phone: +47 98 21 02 31

POLAND
VSL Polska Sp. zo.o
WARSAW
Phone: +48 22849 22 09

PORTUGAL
VSL Sistemas Portugal SA
PAÇO DE ARCOS
Phone: +351 21 445 83 10
Delegação Norte
VILA NOVA DE GAIA
Phone: +351 22 371 18 80

SWITZERLAND
VSL Systems SA
BERNE
Phone: +41 58 456 30 30

SAINT LEGIER
Phone: +41 58 456 30 00

SOUTH AFRICA
VSL Construction Systems SA
BARCELONA
Phone: +39 93 289 23 30

SWEDEN
Internordisk Spännarmering AB
VÄSTERHÄNGE
Phone: +46 10 448 11 42

UNITED KINGDOM
VSL System (UK) Ltd.
LUTON
Phone: +44 148 040 4401

VSL Infrastructure Protection Ltd.
LONDON
Phone: +44 207 803 3614

SINGAPORE
Phone: +65 65 59 12 22

SYDNEY
Phone: +61 2 94 84 5944

Middle East

SULTANATE OF OMAN
VSL Muscat LLC
MUSCAT
Phone: +994 1 885 7225

UNITED ARAB EMIRATES
VSL Middle East LLC
DUBAI, UAE
Phone: +971 4 885 0004

Doha, Qatar
Phone: +974 44 052 444

Asia

BRUNEI
VSL Syths (B) Sdn. Bhd.
BRUNEI DARUSSULAM
Phone: +673 2 380 153 / 381 827

CHINA
VSL Engineering Corp., Ltd.
(China)
HEFEI
Phone: +86 551 382 29 18

HONG KONG
VSL Hong Kong Ltd.
CHAI WAN
Phone: +852 2590 22 88

INDIA
VSL India Private Ltd.
CHENNAI
Phone: +91 44 4225 11 11

INDONESIA
PT VSL Indonesia
JAKARTA
Phone: +62 21 570 07 86

JAPAN
VSL Japan Corporation
TOKYO
Phone: +81 3 3346 8913

KOREA
VSL Korea Co. Ltd.
SEOUL
Phone: +82 2 553 8200

SOUTH AFRICA
VSL Engineers (M) Sdn. Bhd.
KUALA LUMPUR
Phone: +603 7981 47 42

PHILIPPINES
VSL Philippnes Inc.
MANDALUYONG CITY
Phone: +632 722 1703

SINGAPORE
VSL Singapore Pte. Ltd.
SINGAPORE
Phone: +65 6559 12 22

TUNIS
Phone: +971 4 885 7225

VSL Sistemas Portugal SA

AFRICA

ARGENTINA
VSL Sistemas Especiales de Construcción Argentina S.A
BUENOS AIRES
Phone: +54 11 5272 87 52

BOLIVIA
VSL Brasil Construcción e Recuperación Ltda
SÃO PAULO
Phone: +55 11 3521 7153/4

CANADA
CTT Stronghold Canada
TORONTO
Phone: +1 416 477 1042

CHILE
VSL Sistemas Especiales de Construcción S.A
SANTIAGO
Phone: +56 2 2571 6700

COLOMBIA
Sistemas Especiales de Construcción S.A.S
BOGOTA
Phone: +57 1 226 7833

MEXICO
VSL Corporation Mexico S.A de C.V
MEXICO
Phone: +52 55 55 11 20 36

PERU
Sistemas Especiales de Construcción Peru S.A
LIMA
Phone: +51 1 349 38 38

VSL Peru S.A.C
LIMA
Phone: +51 1 713 98 32

UNITED STATES OF AMERICA
VStarstructural LLC
BALTIMORE, MD
Phone: +1 410 850 7000

VSL Offshore Pte Ltd.
SINGAPORE
Phone: +65 65 59 13 05

VSL Philippines Inc.
MANDALUYONG CITY
Phone: +632 722 1703

VSL Sistemas Especiales de Construcción Colombia S.A.
BUENOS AIRES
Phone: +54 11 5272 87 52

VSL Brasil Construção e Recuperação Ltda
SÃO PAULO
Phone: +55 11 3521 7153/4

VSL Sistemas Especiales de Construcción S.A.S
BOGOTA
Phone: +57 1 226 7833

VSL Corporation Mexico S.A de C.V
MEXICO
Phone: +52 55 55 11 20 36

VSL Peru S.A.C
LIMA
Phone: +51 1 349 38 38

VSL Offshore Pte Ltd.
SINGAPORE
Phone: +65 65 59 13 05

VSL Philippine Inc.
MANDALUYONG CITY
Phone: +632 722 1703

VSL Sistemas Especiales de Construcción Colombia S.A.
BUENOS AIRES
Phone: +54 11 5272 87 52

VSL Brasil Construção e Recuperação Ltda
SÃO PAULO
Phone: +55 11 3521 7153/4

VSL Sistemas Especiales de Construcción S.A.S
BOGOTA
Phone: +57 1 226 7833

VSL Corporation Mexico S.A de C.V
MEXICO
Phone: +52 55 55 11 20 36

VSL Peru S.A.C
LIMA
Phone: +51 1 349 38 38

VSL Offshore Pte Ltd.
SINGAPORE
Phone: +65 65 59 13 05

Copyright 2013, VSL International Ltd.
Printed in France – patented.

The information set forth in this brochure including technical and engineering data is presented for general information only. While every effort has been made to ensure its accuracy, this information should not be used or relied upon for any specific application without independent professional examination and verification of its accuracy, suitability and applicability. Anyone using this material assumes any and all liability resulting from such use. VSL disclaims any and all express or implied warranties of merchantability fitness for any general or particular purpose or freedom from infringement of any patent, trademark, or copyright in regard to the information or products contained or referred to herein. Nothing herein contained shall be construed as granting a license, express or implied under any patents.