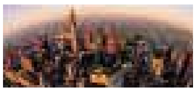
MATERIALS FOR ADVANCED SOLUTIONS



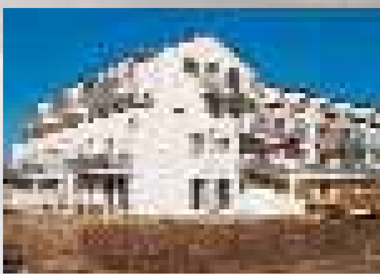
RESILIENT BEDDING OF BUILDINGS

getzner
the good vibrations company

New buildings are increasingly being constructed on sites subject to vibration. Often, the source of the disturbances are railway lines or industrial installations that are close by. In the building, the vibrations can cause excessive amplitudes or an increase in the airborne noise level due to reflection from excited components, e.g. floors or ceilings. The designer is faced with the task of constructing the building in such a way that the specifications of the client are maintained, but the permissible values are not exceeded.

Whether the vibrations in the foundation cause excessive disturbance in the finished building, depends on the excitation strength and frequency, the foundation and the structure of the building. For an evaluation, the excitation must be measured as a function of the frequency whilst the connection of the building to the foundation as well as the structure of the building must be known. A computer model calculation of the vibration system can provide information about the expected vibrations in the building. Where the vibration and consequently the secondary airborne noise exceeds the specified limits, the excitation or transmission into the building must be reduced.

Isolation can be installed at the source or at the recipient. As a matter of principle, a reduction at source is preferable. For disturbances emanating from rail traffic and for the isolation of machine vibrations, there are a wide range of procedures available to reduce the emission. Even so and in many cases, isolation of the source may not be possible for a variety of reasons. The designer then only has the possibility to reduce the vibration and ground-borne noise within the planned building. By means of resilient bedding of the building on Sylomer®, this transmission can be effectively reduced.



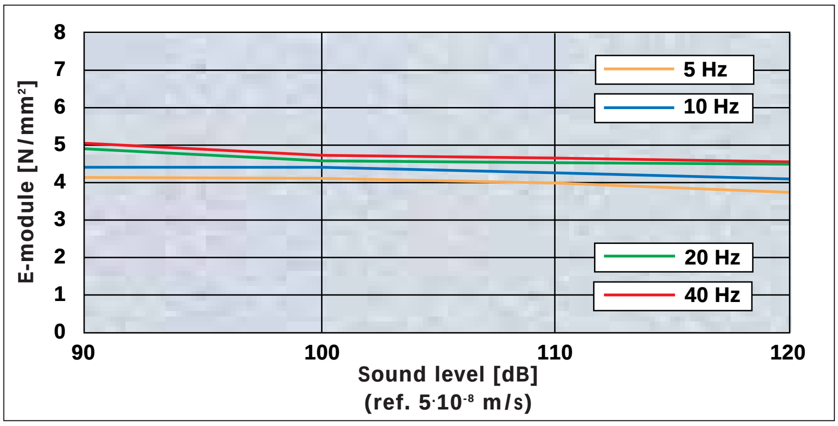
Resilient bedding of buildings

With Sylomer®, the designer has a technical material available for resilient bearing purposes, which suits a multitude of construction methods. The bedding can be provided over the full surface, in strips or at individual bearing points. The specific location at which the building must be resiliently separated is not predetermined for a bedding on Sylomer®. Separation is made wherever it is most favourable for the design.

Characteristics which are essential for effective isolation of a building, are displayed by the material. Sylomer® is volume compressible, i.e. the material does not lose its elasticity even when it is completely encased. Through a wide range of material types, the bedding can be optimally adjusted to the given load supporting areas and the applicable loads. Depending on the Sylomer® type, attenuation is between 7 % and 11 %. Additional damping elements are not normally required.

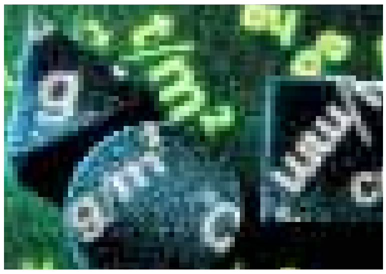
Material

Picture of Sylomer® P, taken with a scanning electron microscope



Amplitude relationship of the dynamic rigidity of Sylomer® S 600 in the usual excitation range for structural applications. Samples: 280 mm x 280 mm x 50 mm

The dynamic stiffness of Sylomer® materials is virtually independent of the excitation amplitude. No stiffening of the bedding is to be expected, even for the smallest amplitudes. The efficacy of the bedding is thus assured for practically all relevant excitation amplitudes. The dynamic stiffness is only slightly dependent on the excitation



frequency. The ratio of dynamic to static rigidity is favourable.

Sylomer® materials are hydrolysis stable as well as being stable towards chemicals, diluted alkaline solutions and oils that are customarily used during construction. Due to the mixed cellular structure, Sylomer® mats can absorb a certain amount of water. The effect of moisture on the static and dynamic stiffness can be disregarded even when in a water saturated condition. Particles of dirt do not penetrate the mat due to the fine cellular surface. Damage due to water is not possible.

To select the suitable Sylomer® type, the specific permanent static load is decisive. This is determined from the bedding area and the effective weight of the finished building. By varying the loaded bedding area, the specific load is adjusted so that it is as close as possible to the load limit for the permanent static load for the respective type. If it is not possible to alter the bedding area, e.g. for full surface bedding, the pressure can be optimized by a combination of various Sylomer® types. The load should be presumed to be the expected weight of the building plus a part of the live load. Shortterm loads, i.e. wind and snow loads, do not have to be taken into account. Depending on the type of building and use, the effective load is normally presumed to be between 60 % and 80 % of the loads considered in the static computation. Brief peak loads up to 4 times the constant static load, can be easily absorbed by Sylomer®.

Once the loads have been calculated and the material type chosen, the resulting performance of the resilient layer is the natural frequency. The desired performance is adjusted by means of the resilient layer. With increased thickness the natural frequency is reduced. The frequency of the system is also effected by the mass of the structure whereby the greater the mass of the structure being excited, the lower the natural frequency. With the greater mass, the resilient layer should be chosen to be stiffer. The natural frequency should be chosen with regard to the disturbing frequency range.

Often loads vary at different parts of the building. Depending on the load, different Sylomer® types are used for the resilient layer. Through suitable selection of the type of bedding material and a variation in the loaded area, it is possible to ensure all types are loaded close to the limit for their permanent static loads. With the same thickness, a uniform cushioning for all types is achieved resulting in virtually the same natural frequencies.

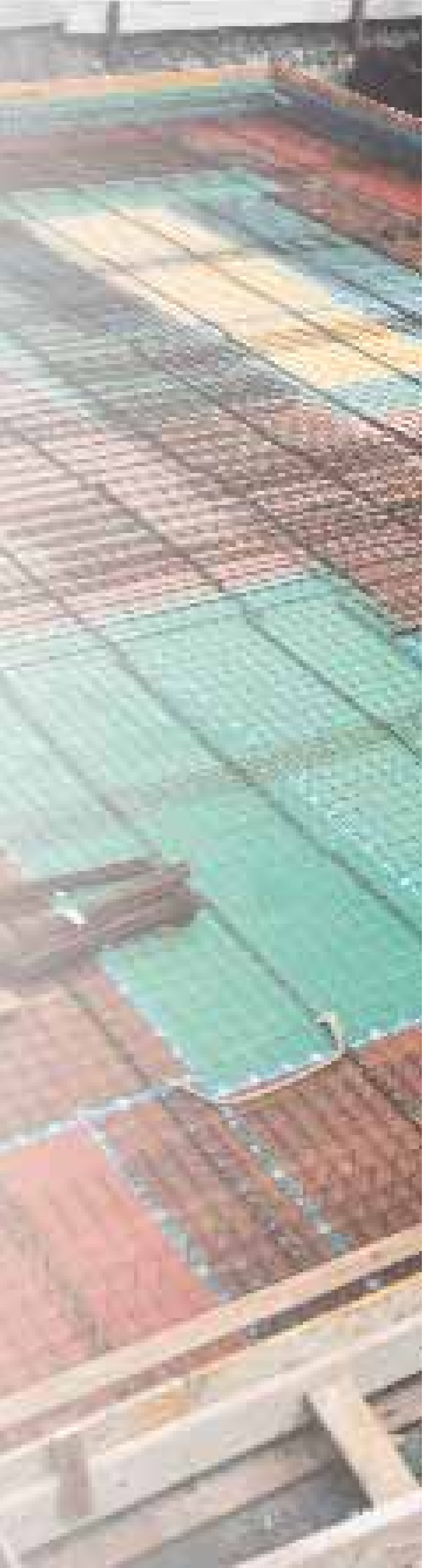
Design

Bedding thickness [mm]	Natural frequency [Hz]
25	**13**
37	**11**
50	**9**
75	**8**

Typical natural frequencies for structural bedding on Sylomer®

The constant static load should be between 10 kN/m^2 and 1000 kN/m^2 for resilient structural bedding on Sylomer®.

Brief peak loads up to 4 times the permanent static load can be easily absorbed by Sylomer®.

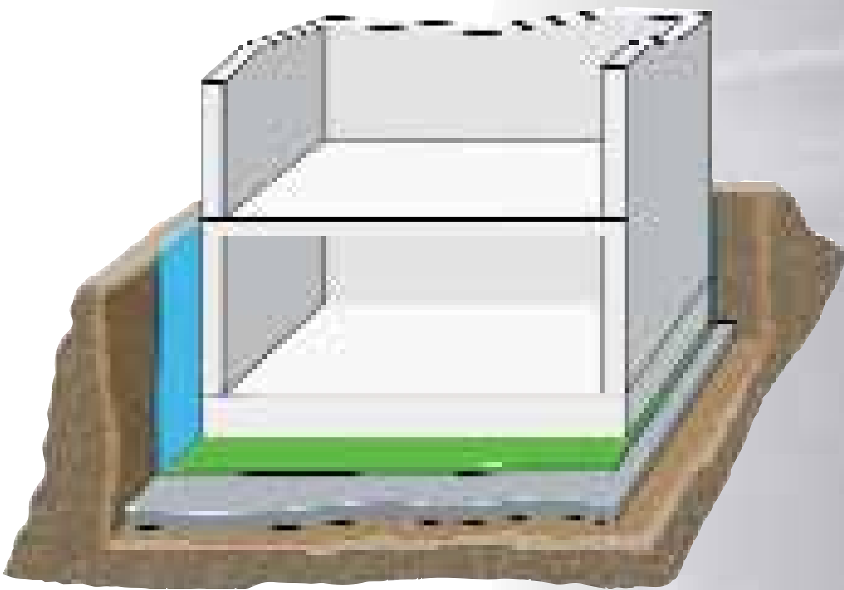


The bedding on Sylomer® can be full surface, on strips or on point bearings. The bearing design for the building depends on the specific natural frequency and the construction features. Connecting structures, such as ceilings or walls, can be of in-situ concrete or can be prefabricated. When cast from in-situ concrete, the bedding surface is normally utilized as lost formwork. The reinforcement can be fitted directly on the mats. For very soft Sylomer® types, the bedding area of the spacer mounts should be enlarged by suitable bearers, so that the reinforcement does not puncture the mats. Prefabricated components are simply placed on the bedding. Resiliently mounted floors should normally be reinforced. For complete decoupling of the building, all walls above the resilient bedding, which are in contact with the ground, must be resiliently isolated.

Construction

A full surface bearing has the advantage of a simple construction method and the risk of vibration transmission due to installation errors is slight. Separation is normally made between the sub-base or a concrete blinding layer and the floor slab. For good efficacy, the foundation should be as rigid as possible. The structural loads are distributed evenly into the ground through the full surface resilient layer and construction methods to transfer the loads to strips or individual bearings are not necessary. Structural vibrations of the floor slab are virtually avoided by the full surface bearing.

Full surface bearing



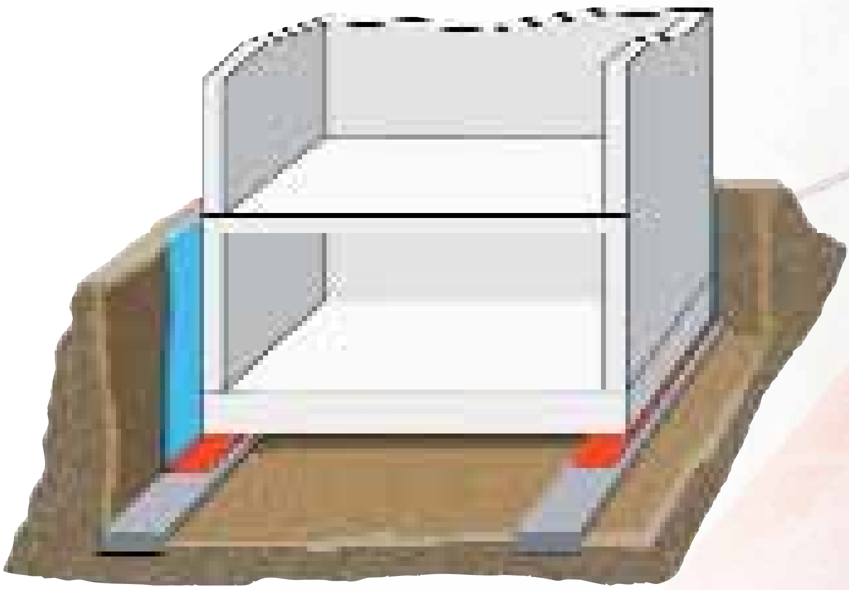
Where the load is transmitted lineally, the use of strip bedding is possible. The resilient layer is normally located within the foundation area or directly below the basement floor. Alternatively, the basement floor slab and consequently the basement ceiling/first floor slab and supporting walls can be placed directly on the bedding strips. To effectively isolate structural vibrations, the construction elements adjacent to the resilient layer should be very rigid and should not show any noticeable resonance behaviour.

By placing the resilient layer on the strip foundation, the advantage once this is completed, is that the building can be erected in the normal way.

Subsequent vibration transmission due to structural bridging is virtually excluded.

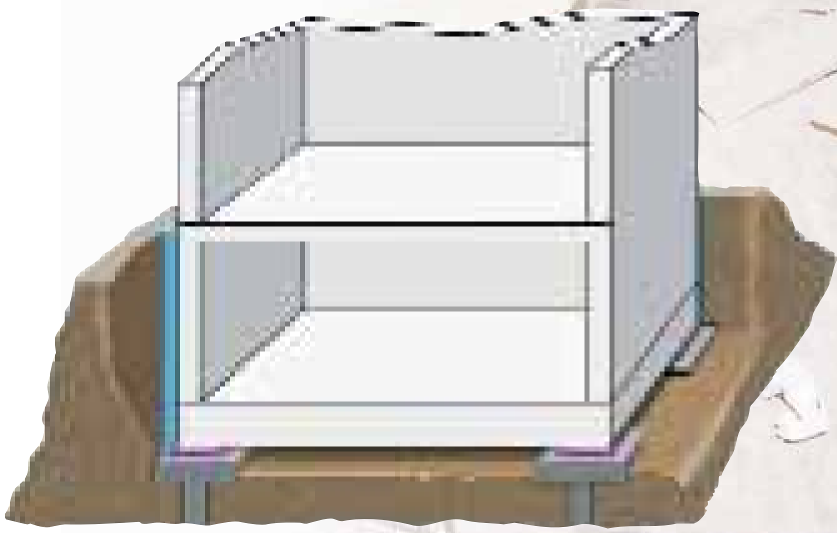
With a separation layer below the first floor slab/basement ceiling, lateral isolation of the basement walls can be eliminated. However, all connections between the basement and resiliently mounted structural components, such as, i.e. stairs and service penetrations, must in addition be resiliently separated.

Strip bearings



With pile foundations or the bedding of individual points or columns, the resilient isolation can be provided by individual bearings. The applicable load determines the suitable bedding type. The bedding area can be adapted, where necessary, by attached pile caps, so that the optimum compression is achieved for the specified Sylomer® type. For point bearings, very high loads are supported. As with full surface and strip bearings, the foundation beneath the bearings and its neighbouring foundation structure should be rigid.

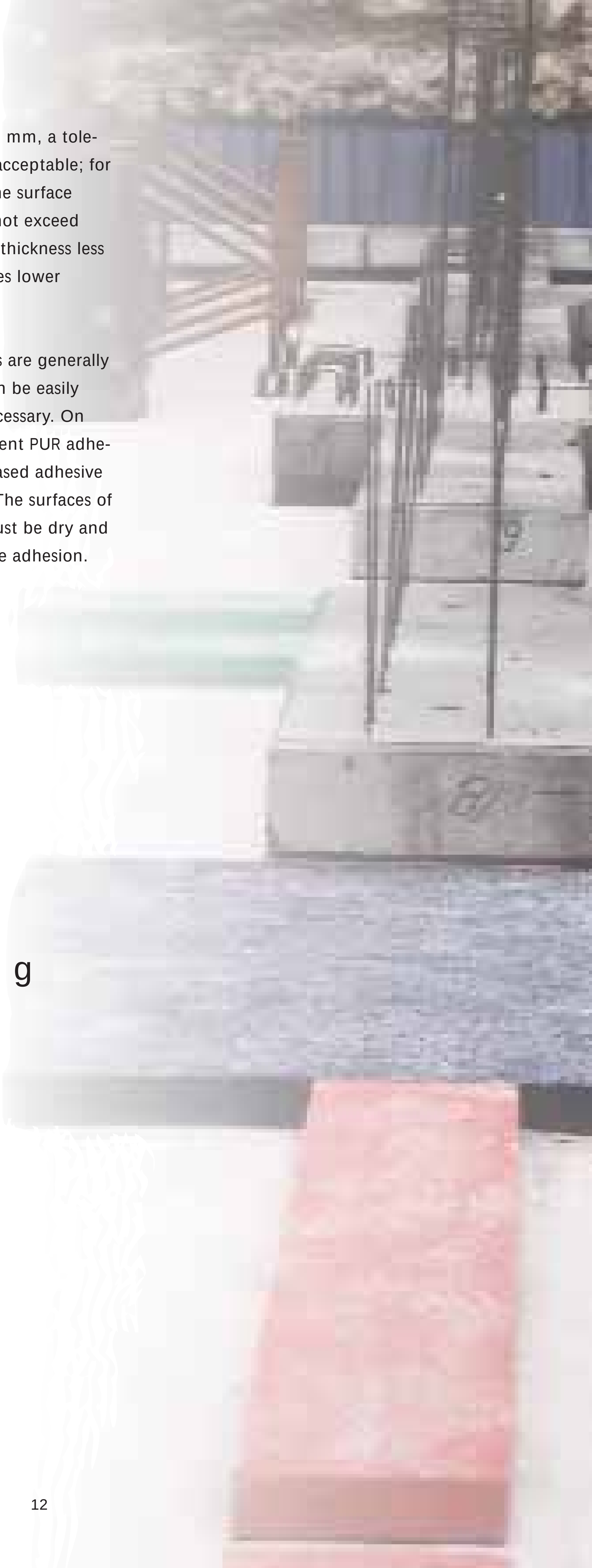
Point bearings



Sylomer® sheets and the bearings they form, are flexible and adapt to the contours of the foundation when loaded. The stiffness of the bearing depends on the load it supports and increases with this accordingly.

The surface of the foundation should be flat and free from sharp edged depressions or protrusions. Concrete surfaces are to be tamped and smoothed with the surface finish depending on the thickness of the bedding material. For a bedding thickness up to 25 mm, a tolerance of 3 mm is acceptable; for thicker bedding the surface tolerance should not exceed 5 mm. A bedding thickness less than 8 mm requires lower surface tolerance.

Sylomer® materials are generally laid loose, but, can be easily bonded where necessary. On site, dual-component PUR adhesive or bitumen based adhesive is normally used. The surfaces of the foundation must be dry and swept clean for the adhesion.



Preparation of the foundation/bonding

Sylomer® bedding is supplied to site in sheets or cut to size as individual bearings. Cutting on site is possible with standard tools.

For full surface bearings, the sheets (in rolls) are initially distributed around the site and rolled out on the base in accordance with the plans. The sheets should be left unrolled for some time to allow the material to expand, settle and adapt to the ambient conditions. The sheets can then be finally positioned, and cut to shape, inserting off-cuts to fill gaps. Pieces should be butt jointed and covered with an adhesive tape. With multiple layers, the sheets should be laid offset from the previous layer. To prevent movement, the mats may be spot bonded.

Strip and point bearings can if required, be supplied to site numbered, according to the laying plan. The bearings then only need be positioned and bonded where necessary, at the intended locations where the resilient bearings do not fully cover the foundation, and to avoid the risk of a bridging, a soft paper faced quilt can be inserted. Butt joints should be covered with adhesive tape. Formwork should be placed at the sides of the slab to be cast, with additional Sylomer® layers fixed vertically to these if required. Concrete can then be poured directly onto the Sylomer® bearing, ensuring no concrete is allowed to escape or penetrate the joints to form a bridge. When using softer more open cell Sylomer® types, a polythene membrane may be required.

Installation

The expected effectiveness of the resilient bedding is a system dimension, which is determined by the dynamic bedding characteristics, the dynamically effective building mass and the vibration resistance of the foundation (high mechanical initial impedance). Natural frequency is determined by the elasticity of the bearing and the effective building mass. Vibration that exceeds √2 x natural frequency is reduced in varying degrees. Excitations at or below √2 x natural frequency are amplified. With high inherent damping of Sylomer® materials however, this amplification can be kept low. As dynamic loads are introduced, and as these frequencies become higher, a general stiffening effect occurs in the resilient layer. Due to the highly elastic nature of Sylomer® this stiffening is lower than would often be observed. To allow for as much of the mass of the building as possible to become dynamically effective, the foundation should be as rigid as possible. The natural frequency is normally specified to isolate the lower exciting frequencies.

The range of disturbing frequencies must be fully measured and understood so that the natural frequency can be calculated to isolate effectively. This can be done beforehand based on material test data, to indicate if the proposed solution will be effective and compare to a non-isolated structure.

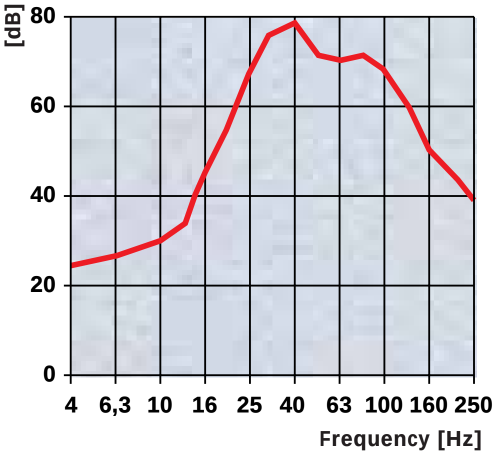
The resonant frequencies of other components of the structure must also be taken into account i.e. floors and walls. By using a resilient layer to alter the natural frequency of the building one must ensure this will have no adverse effect on these components.

Measurements on a building bedded on Sylomer® strips in the foundation, are shown in the adjacent diagrams.

Performance and creep behaviour

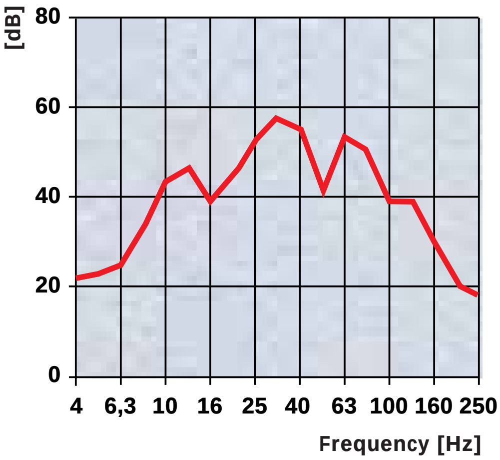
Third octave band vibration level (FAST*, KB evaluated dB re $5 \cdot 10^{-8}$ m/s) when excited by a passing rapid transit train. Measured in the ground directly next to the building.

*FAST, max. hold all



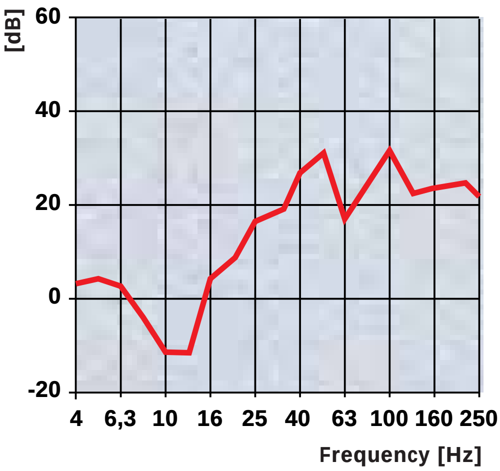
Third octave band vibration level (FAST*, KB evaluated dB re $5 \cdot 10^{-8}$ m/s) of the vibrations in the building. Measured on the un-plastered ceiling.

*FAST, max. hold all



Difference in the third octave band vibration level next to the building and on the un-plastered ceiling as a dimension for the efficacy of the resilient bedding.

Measurements:
imb dynamik
Ing.-Büro Dr. Müller-Boruttau,
D-82266 Inning-Buch



Creep behaviour

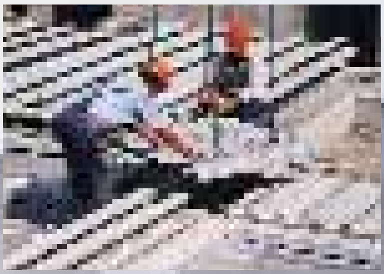
The creep behaviour of Sylomer® has been thoroughly tested and comprehensively documented, both at Getzner as well as at external testing institutes. Stiffening of the bearings is minor when installed within the materials load limits. The additional deflection under constant load (creep) is precisely known and specified for each Sylomer® type. The precise data is shown as a function of the load in the product data sheets.

Little alteration in the material characteristics was observed on built projects tested after up to 20 years in use. Due to the excellent creep behaviour and the fact that Sylomer® bearings are completely maintenance free, when fitted, they do not need to be accessible. Complex constructions are not required to provide access for maintenance to, or subsequent exchange of the bearings.

Stockholm	Residential building Södrastation	Vibration isolated foundation for a 6-storey residential building in the direct vicinity of a railway line.	1988
Nuremberg	Extension to a hotel	Resilient foundation on individual bearings as protection against an underground railway tunnel running directly beneath the building.	1991
Barcelona	Theatro National de Catalunya	Full surface bedding of the complete floor slab. The excitation arises from an underground railway line adjacent to the building.	1992
Nuremberg	New multi-storey residential building	Strip bearing in the foundation area as protection against the subway tunnel running directly beneath the building.	1994
Mainz	Dorint Hotel	Full surface bedding of the floor slab as protection against the main-line railway tunnel running directly beneath the building.	1994
Munich	New town houses	Resilient separation between the basement walls and the basement floor. Excitation is caused by a railway line close by.	1995
Cologne	Day nursery Eigelstein	Isolation of 2 wings of the building from a neighbouring main-line railway.	1995
London	New houses	Strip bearings, to protect new buildings from the vibrations of an adjacent railway line.	1995

References
(extract)

Landsberg	Power station Mühlbach	Full surface bedding of the complete turbine building as well as the intake and outlet ducts. The neighbouring buildings are protected from the vibrations from power station operation.	1996
Eching near Munich	New apartments	Resilient separation between the basement walls and the basement floor. Excitation occurs from the privately run railway line close by.	1996
Berlin	Haus Sommer	Strip bearing above a rapid transit railway tunnel directly beneath the building.	1996
Stockholm	New residential and commercial buildings	Resilient separation of building foundations from the railway tunnel beneath	1994 to 1997
Höhenkirchen near Munich	New apartment buildings with owner-occupied apartments	Resilient bedding of the complete building on strip and point bearings. The bearings are located between the strip foundations and the floor slab. Excitation arises from a rapid transit line next to the buildings	1995 to 1997
Munich	Extension to the Chamber of Industry and Commerce	Resilient separation of the walls as protection against a railway line close by.	1997
Feldafing near Munich	Prefabricated detached house	Strip bearing in the foundation as protection from an adjacent railway line	1997
Salzburg	New multi-storey residential complex with nursery	Resilient bedding of the reinforced concrete slab on the flat roof of the nursery to isolate footfall and impact sound.	1997



Höhenkirchen near Munich, new building of apartment buildings

Stockholm, residential building Södrastation

Berlin, Haus Sommer

Barcelona, Theatro National de Catalunya

Mainz, Dorint Hotel

Sylomer® and Sylodyn® approved in practice:

High demands are made on Sylomer® and Sylodyn®. They are needed for diverse application to produce high isolation levels and resistance to conditions in a variety of different locations.
Our materials have been examined for serviceability and efficiency in our laboratory as well as by renowned institutes.
The following institutes, among others, have conducted tests:

- Bundesversuchs- und Forschungsanstalt (Federal Experimentation and Research Institute), Arsenal, Vienna
- Fraunhofer Institut für Bauphysik (Fraunhofer Institute of Construction Physics), Stuttgart
- Prüf- und Versuchsanstalt der Magistratsabteilung 39 der Stadt Wien (Test and Experimentation Institute of Local Government Department No. 39 of the City of Vienna)

- Technischer Überwachungsverein Rheinland, Institute für Umweltschutz (Technical Supervisory Service of the Rhineland, Environmental Protection Institute), Cologne
- Technische Universität München (Munich Technical University), Prüfamt für Bau von Landverkehrswegen (Test Office for the Construction of Overland Transportation Routes)
- Müller-BBM GmbH, Planegg near Munich

Sylomer® and Sylodyn® are resistant to oil, grease, diluted acids and alkaline solutions and remain elastic even at low temperatures. The physical and chemical qualities of our products have been documented in material and product data sheets. These data sheets and literature detailing other areas of application are readily available for your information. Our technicial department can offer engineering solutions, testing or calculations for Sylomer® and Sylodyn® for your particular application.

Certified
EN ISO 9001

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