MAURER Earthquake Protection Systems
As unique as the buildings they protect
MAURER Earthquake Protection Systems

Content

Structural Protection Systems P. 04

Structural Analysis P. 05

Basic Concepts of Earthquake Protection P. 06

Hydraulic Coupling and Damping Elements P. 08
   >> Permanent Restraints (HK; HKE) P. 08
   >> Shock Transmission Unit (MSTU) P. 08
   >> Shock Transmitter with Load Limiter (MSTL) P. 08

Bearing Elements for Base Isolation P. 10
   >> Elastomeric Isolators P. 10
   >> Sliding Isolators P. 12
   >> Hydraulic Dampers (MHD) P. 14

Steel Hysteretic Dampers P. 16

Structural Expansion Joints P. 18
   >> Earthquake Expansion Joints for Road Bridges P. 18
   >> Swivel-Joist Expansion Joints of Type DS P. 20
   >> Fuse Box for Modular Joints P. 21

Project-Specific Testing P. 22

References P. 25
MAURER Structural Protection Systems  
– as unique as the buildings they protect

>> “Earthquakes are natural disasters whose feature is that most of the human and economic losses are not due to the earthquake mechanisms, but to failures in man-made facilities, like buildings, bridges etc., which supposedly were designed and constructed for the comfort of the human beings.” (Bertero)

The above observation brings a note of optimism and is encouraging because it tells us that, in the long run, seismic problems are solvable in principle. The task of solving these problems is attributed to Seismic Engineering. The advances in this field have already played a significant role in reducing seismic hazards through the improvement of the built environment, finally making possible the design and construction of earthquake-resistant structures. Progress has mainly been the result of newly developed design strategies, e.g. Base Isolation, which could not have found useful application without the parallel development of the “seismic hardware” needed for their implementation.

Thus, several research laboratories and industrial concerns have invented and perfected a series of devices that exploit well known physical phenomena which have been adapted to the protection of structures.

MAURER has distinguished itself in this very real race, when in the middle of the 1990s MAURER decided to invest both in human and financial resources, that have led to its present position of worldwide leadership.

>> The purpose of this brochure is:

A) to illustrate the manner in which MAURER has faced and solved the problems deriving from the practical application of the new design strategies.

B) to present the devices that have been developed and perfected towards this goal.

MAURER’s philosophy is to design its devices on a case-by-case basis, i.e. the “tailor-made” concept, with evident advantages for the customer.

World map of the most affected earthquake zones

Acropolis Museum, Athens
MAURER is more than a supplier of Seismic Hardware

MAURER has acquired a vast experience in the application of modern seismic protection technologies within a wide variety of structures to minimise earthquake induced damage.

MAURER’s experts offer structural designers and architects assistance in the definition of the protection systems and in the selection of devices best suited for each case, considering not only the seismicity of the site, but also the structural, functional and architectural requirements.

MAURER's experts offer structural designers and architects assistance in the definition of the protection systems and in the selection of devices best suited for each case, considering not only the seismicity of the site, but also the structural, functional and architectural requirements.

The efficiency and reliability of the proposed structural protection system is validated by time-based simulation of the structure with earthquake protection system considering all relevant nonlinearities of the entire system.

Better adaptation thanks to a wider range of Seismic Hardware

The designer may choose from a great variety of seismic devices in order to achieve the optimum seismic protection of the structure. Therefore, MAURER offers the world’s most extensive range of seismic devices. Our specialists always develop the best earthquake protection system for your requirements.
Seismic Analysis – a tool to optimize through our devices your Seismic Protection System

The linear or modal analysis represents the most often adopted method to predict the structural response in terms of forces and drift due to seismic impact and to design the structural protection system. In this case, the seismic input is defined by the "elastic response spectrum". This method may be used if a set of conditions are met of which the most important is the effective damping ratio that must not be greater than 30%.

The more accurate method represents the nonlinear time history analysis where all relevant nonlinearities of the structure and seismic protection system are considered in the modelling and limitations on any characteristic values do not exist. In this case, the seismic input is defined by a set (at least 7, better 20) of ground acceleration time histories, commonly denoted as accelerograms. To conduct the nonlinear time history analyses the following data are required:

- **Structural data**
  - Structural drawings, cross sections (deck, abutment, pier),
  - moment of inertia, torsion constant, shear stiffness,
  - materials (modulus of elasticity, shear modulus, density, etc.), foundation (dimensions, Winkler - modulus, etc).

- **Earthquake data**
  - Response spectrum, compatible or site-specific accelerograms, loads under seismic conditions, allowable bending moments, shear and axial forces, displacements and any further specific requirements of the designer.

---

**Advantages of MAURER Nonlinear Structural Analysis**

- **Optimization of seismic protection system** in terms of efficiency and economy.
- Precise evaluation of actual safety margins within the structure and the seismic devices.
- Evaluation of considerable structural cost savings based on less reinforcement and savings in terms of steel and concrete.
- Validation of designer’s analysis through the numeric analysis by MAURER.
- Precise evaluation of the isolation system’s re-centring capability.
- Accurate prediction of shear forces that affect the isolators and the structure as a whole.
- Accurate determination of structural drifts and torsional effects.

Axonometric view of a rail-way bridge, 3D mathematical model
Structural protection through two basic concepts of earthquake protection

Having specified the structural protection required, the seismic engineer evaluates the most reasonable seismic protection strategy considering the characteristics of the structure, the site-specific ground motion data and respecting the European Standards in seismic engineering. Today, seismic engineers can rely upon numerous technical solutions based on various types of well-established strengthening methods and anti-seismic devices.

1. Provide the structural members with adequate flexibility, strength and ductility to reduce displacements by their stiffness and dissipate energy through plastic deformation; these solutions are referred to as “strengthening” or “conventional design” approaches.

2. Protecting the structure against earthquake-induced damage by limiting the seismic effects through the use of devices properly inserted into the structure; these devices are referred to as “anti-seismic devices”.

The flowchart below places into perspective the two basic concepts of structural protection against earthquake impact and shows the associated types of anti-seismic devices.

1. Fit the structure with permanent restraints only, proportioning its structural members with adequate flexibility, strength and ductility.

2. Insert at appropriate locations of the structure temporary restraint devices, which allow slow thermal movements and lock-up for impacts in case of earthquakes.

The superior seismic behavior of hyperstatic structures, and in particular of bridges, is well known. The reason for this fact is that in hyperstatic structures all structural members are forced to work together at a critical moment. However, especially in the case of bridges, construction techniques such as the use of prefabricated beams and the possible differential settling on the foundations lead to the choice of isostatic arrangements. The advantages of the two concepts can be maintained through the adoption of hydraulic Shock Transmitters.
Basic Concepts of Earthquake Protection

>> Decoupling and Damping

In the flowchart the alternative to structural reinforcement is structural Decoupling and Damping, which is the most effective to protect structures from the hazardous impact of earthquakes. The latter can be obtained through:

- Seismic Isolation,
- Energy Dissipation, or, better of a combination of both

Seismic Isolation is by far the most used approach to significantly reduce the structural response due to seismic excitation. A proper isolation system must be capable of appropriately ensuring the following four main functions:

- Vertical load transmission
- Lateral flexibility (Decoupling)
- Energy dissipation (Damping)
- Re-centring capability

In addition, the isolation system shall provide a defined minimum base shear as locking force against non-seismic forces, e.g. wind forces.

Some types of isolators intrinsically possess this function; for others, one must resort to the so-called “Fuse Restraints”. MAURER has developed several types of both mechanical and hydraulic Fuse Restraints.

If the adoption of Seismic Isolation is not feasible and the structure possesses sufficient flexibility, i.e. important relative displacements occur during an earthquake due to elastic deformation of its structural elements, then Energy Dissipation (Damping) can be effectively used to attain Seismic Mitigation. This is achieved through the adoption of Hysteretic Dampers or Hydraulic Dampers, which are installed in the structure at appropriate locations. Skilled MAURER engineers are available to assist designers in choosing the most appropriate Seismic Hardware on a case-by-case basis, as well as optimizing the adopted solution in terms of performance, costs, reliability, durability and other project-specific criteria.

Djamaâ El Djazïr Mosque, Algiers: base isolation by Sliding Isolators combined with adaptive Hydraulic Dampers
MAURER Restraint Systems for Strengthening

Even if permanent restraints represent the family of the conceptually simplest seismic hardware, nonetheless they comprise a large variety of devices. Thus their standardization is problematic and MAURER has adopted the strategy of the “tailor-made” design according to the specifications given by the designers. These restraints can be designed to laterally hold the structure in X and Y directions up to a certain load (HK device) or guide it in one direction (unidirectional = HKE device) only.

**Shock Transmission Unit (MSTU)**

Shock Transmitters are devices that allow for movements at lowest velocities (<0.1 mm/s) without appreciable resistance (1-4% F_{max}), but produce high forces at higher velocities to hold the structure in position without noticeable displacement in the STU (0.5–3% of stroke capacity in loaded direction).

In the Shock Transmitter developed by MAURER, denoted as MSTU, both resistance to thermally induced movements and deformations due to earthquakes have been minimized thanks to the adoption of function, special materials, accurate design procedures and proprietary fabrication processes.

The MSTU activation or lock-up velocity v_0 is adjusted to the designer’s specified value which is typically between 0.1 and 1.5 mm/s but may reach 5 mm/s in case of very large structures.

**Shock Transmitter with Load Limiter (MSTL)**

The European Standard EN 15129 requires that the reliability factor of Shock Transmitters on their design force F_d shall be \( \gamma_x = 1.5 \), unless an overload protection system or “load limiter” is incorporated. In this case, the value of the reliability factor can be reduced to \( \gamma_x = 1.1 \). Hence, the adoption of MSTLs decreases the forces acting on the structural members by 27%. It increases the overall safety of the devices and the structure as it is granted that all devices in serial and parallel arrangement are equally and simultaneously loaded when affected by sudden service or seismic impacts. This is not the case for classic STUs that might be overloaded by a force even greater than 1.5 times the design force F_d. Therefore the MSTL application reduces the costs of the structural members and even the cost of the Shock Transmitter itself because MSTLs are more compact than MSTUs. Thus, the MSTL providing additional technical benefits and reliability is also the most economical solution.
Hydraulic Coupling and Restraint Systems

Shock Transmitter MSTU/MSTL

Key Characteristics of MAURER Shock Transmitters MSTU/MSTL

- Load limiter function for $F_d$. Possible overall structural cost reduction thanks to the use of MSTLs in the range of 1–5%.

- High rigidity with immediate lock-up of structure within max. 1–3 mm STU relative motion possible (depending on stroke).

- No wear and low static friction resistance in the adopted triple-seal-guide system granting at least 50 years of service life without leaking.

- Suitable for extreme climate zones.

- Absolutely maintenance-free device → reliability and safety during entire service life.

- Max. pressure is limited to 50 MPa for ultimate and 25 MPa for service load cases whereby leaking is effectively prevented.

- CE-marking is available for all devices.

Preliminary dimensions based on:

- Max. inner operating pressure for ultimate load case: $p = 50$ MPa (500 bar) incl. $\gamma_x$

- Max. inner operating pressure for service load case: $p = 25$ MPa (250 bar) incl. $\gamma_x$

- Operating temperature range -40 to +40 °C

- Considered SLS load duty cycles 100,000 considering $0.7 \times N_d$

- Damping exponent $\alpha = 0.04$ for MSTL

- Adjustable lock-up velocity $v_0 = 0.2–5$ mm/s

|MSTU| MSTL |
|---|---|---|---|---|---|---|---|
| | L1 | L0 | HP | BP | L1 | L0 | HP | BP |
| [mm] | [mm] | [mm] | [mm] | [mm] | [mm] | [mm] | [mm] | [mm] |
| 500 | 2,000 | 1,700 | 450 | 380 | 1,930 | 1,650 | 400 | 350 |
| 1,000 | 2,220 | 1,880 | 500 | 410 | 2,120 | 1,800 | 450 | 380 |
| 1,500 | 2,460 | 2,060 | 550 | 450 | 2,340 | 1,960 | 500 | 410 |
| 2,000 | 2,680 | 2,260 | 600 | 490 | 2,510 | 2,110 | 550 | 450 |
| 2,500 | 2,890 | 2,430 | 650 | 550 | 2,700 | 2,260 | 600 | 490 |
| 3,000 | 3,070 | 2,590 | 700 | 600 | 2,850 | 2,390 | 650 | 550 |
| 3,500 | 3,280 | 2,760 | 800 | 660 | 3,020 | 2,520 | 700 | 600 |
| 4,000 | 3,480 | 2,920 | 850 | 700 | 3,190 | 2,650 | 750 | 630 |
| 4,500 | 3,700 | 3,100 | 900 | 750 | 3,370 | 2,790 | 800 | 660 |
| 5,000 | 3,900 | 3,280 | 950 | 800 | 3,540 | 2,940 | 850 | 700 |
| 5,500 | 4,110 | 3,450 | 1,050 | 860 | 3,720 | 3,080 | 900 | 750 |
| 6,000 | 4,310 | 3,630 | 1,100 | 900 | 3,890 | 3,230 | 950 | 800 |
| 6,500 | 4,620 | 3,800 | 1,150 | 950 | 4,180 | 3,380 | 1,000 | 830 |
| 7,000 | 4,700 | 3,980 | 1,250 | 1,000 | 4,240 | 3,540 | 1,050 | 860 |
| 7,500 | 4,900 | 4,160 | 1,300 | 1,050 | 4,420 | 3,700 | 1,100 | 900 |
| 8,000 | 5,130 | 4,350 | 1,350 | 1,100 | 4,620 | 3,860 | 1,150 | 950 |

$F_d$: design force provided by designer for ULS load case not including reliability factor $\gamma_x = 1.5$ for MSTU and $\gamma_x = 1.1$ for MSTL (see EN 15129)

$L1$, $L0$, HP, BP: dimensions include reliability factor $\gamma_x = 1.5$ for MSTU and $\gamma_x = 1.1$ for MSTL on design force $F_d$.

Length of the anchoring 550 mm, variable amount depending on design forces.
MAURER Bearing Systems for Base Isolation and Mitigation

>> Elastomeric Isolators

MAURER Elastomeric Isolators decouple structures from their foundations during an earthquake, thereby reducing the seismic impact on the building. Elastomeric Isolators are well-established elastomer-based bearings that decouple the structure by shear deformation and add damping to the structure by damage-free deformation of the elastomer molecules. The isolators transfer the vertical loads from the structure to the foundation while at the same time allowing for rotation and elastic re-centring.

>> Classification based on mixture and structure

1. Elastomeric Isolators with Low Damping
   **MLDRB = Low Damping Rubber Bearing**
   These devices are made of several layers of rubber separated by vulcanized steel sheets. The isolation is attained through the shear deformation of the rubber layers. The energy dissipation is poor whereby additional dampers are required to increase structural damping and decrease structural displacements.

2. Elastomeric Isolators with High Damping
   **MHDRB = High Damping Rubber Bearing**
   The different molecular structure of high-damping rubbers (HDR) allows dissipating more energy than for LDRB. This results in effective damping ratios ranging from 6 % to 10 % and therefore a slightly fatter hysteretic loop is obtained. As the energy dissipation is still limited also HDRB are often combined with additional dampers to reduce structural drifts in case of severe earthquakes.

3. Elastomeric Isolators with Lead Core
   **MLRB = Lead Rubber Bearing**
   To increase the effective damping ratio up to 40 %, one or more lead cores are integrated vertically in the elastomeric isolator. When subjected to horizontal deformation, the lead core produces significant greater hysteretic damping than Low and High Damping Rubber Isolators. The resulting force displacement loop is much fatter, i.e. much more energy is dissipated per cycle, which is the reason why LRBs are the most used Elastomeric Isolators.
**Bearing Elements for Base Isolation**

**Preliminary dimensions based on:**
- Effective Damping Ratio: 20%
- Temperature range: -25 °C to +50 °C for service load case; -13 °C to +45 °C for maximum credible seismic load case
- Shear modulus: 0.9 N/mm²
- Total displacement \(d_{\text{max}}\) including recommended reliability factors as per EN 1998 (\(\gamma_x = 1.2\) for buildings and \(\gamma_x = 1.5\) for bridges)

**Typical parameters:**
1. Shear modulus: 0.4 to 1.35 N/mm²
2. Effective Damping Ratio: \(-15\%\) to \(-35\%\)
3. Sizes up to: 1,200 x 1,200 x 550 mm, diameter 1,200 x 550 mm

<table>
<thead>
<tr>
<th>(N_{\text{ed}})</th>
<th>(N_{\text{ed,max}})</th>
<th>(d)</th>
<th>(d_{\text{max}})</th>
<th>(D_1)</th>
<th>(D_2)</th>
<th>(H1)</th>
<th>(a)</th>
<th>(b)</th>
<th>(A)</th>
<th>(B)</th>
<th>(H2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>[kN]</td>
<td>[kN]</td>
<td>[mm]</td>
<td>[mm]</td>
<td>[mm]</td>
<td>[mm]</td>
<td>[mm]</td>
<td>[mm]</td>
<td>[mm]</td>
<td>[mm]</td>
<td>[mm]</td>
<td>[mm]</td>
</tr>
<tr>
<td>700</td>
<td>1,000</td>
<td>50</td>
<td>200</td>
<td>400</td>
<td>600</td>
<td>200</td>
<td>400</td>
<td>400</td>
<td>600</td>
<td>450</td>
<td>210</td>
</tr>
<tr>
<td>2,100</td>
<td>3,000</td>
<td>50</td>
<td>200</td>
<td>500</td>
<td>700</td>
<td>240</td>
<td>500</td>
<td>500</td>
<td>700</td>
<td>550</td>
<td>270</td>
</tr>
<tr>
<td>3,500</td>
<td>5,000</td>
<td>50</td>
<td>200</td>
<td>600</td>
<td>800</td>
<td>300</td>
<td>600</td>
<td>500</td>
<td>800</td>
<td>550</td>
<td>300</td>
</tr>
<tr>
<td>4,900</td>
<td>7,000</td>
<td>50</td>
<td>200</td>
<td>700</td>
<td>800</td>
<td>300</td>
<td>600</td>
<td>600</td>
<td>800</td>
<td>650</td>
<td>310</td>
</tr>
<tr>
<td>6,300</td>
<td>9,000</td>
<td>50</td>
<td>200</td>
<td>700</td>
<td>900</td>
<td>300</td>
<td>600</td>
<td>600</td>
<td>800</td>
<td>650</td>
<td>310</td>
</tr>
<tr>
<td>7,700</td>
<td>11,000</td>
<td>100</td>
<td>300</td>
<td>700</td>
<td>900</td>
<td>330</td>
<td>700</td>
<td>700</td>
<td>900</td>
<td>750</td>
<td>340</td>
</tr>
<tr>
<td>9,100</td>
<td>13,000</td>
<td>100</td>
<td>300</td>
<td>800</td>
<td>1,000</td>
<td>360</td>
<td>700</td>
<td>700</td>
<td>900</td>
<td>750</td>
<td>340</td>
</tr>
<tr>
<td>10,500</td>
<td>15,000</td>
<td>100</td>
<td>300</td>
<td>800</td>
<td>1,000</td>
<td>360</td>
<td>700</td>
<td>700</td>
<td>900</td>
<td>750</td>
<td>340</td>
</tr>
<tr>
<td>14,000</td>
<td>20,000</td>
<td>100</td>
<td>300</td>
<td>900</td>
<td>1,100</td>
<td>360</td>
<td>800</td>
<td>700</td>
<td>1,000</td>
<td>750</td>
<td>340</td>
</tr>
<tr>
<td>17,500</td>
<td>25,000</td>
<td>100</td>
<td>300</td>
<td>900</td>
<td>1,100</td>
<td>360</td>
<td>800</td>
<td>800</td>
<td>1,000</td>
<td>850</td>
<td>370</td>
</tr>
<tr>
<td>21,000</td>
<td>30,000</td>
<td>100</td>
<td>300</td>
<td>900</td>
<td>1,100</td>
<td>390</td>
<td>900</td>
<td>900</td>
<td>1,100</td>
<td>950</td>
<td>370</td>
</tr>
</tbody>
</table>

\(N_{\text{ed}}\) = max. vertical design load combined with service displacements \(d\)

\(N_{\text{ed,max}}\) = max. vertical earthquake load combined with \(d_{\text{max}}\)

\(d\) = service displacement due to temperature effects, traffic loads, etc.

\(d_{\text{max}}\) = total displacement for earthquake combined with service condition

\(H1\) = overall height of round bearing

\(H2\) = overall height of rectangular bearing

Additional tables with different shear modulus, displacement and loads are available (see technical information TI_003).

**Key Characteristics of MAURER Elastomeric Isolators**

- Great durability of high quality MAURER synthetic chloroprene or natural rubber compounds for a life span of 20 to 40 years; less ageing effects by chloroprene rubber compounds.

- Effective Damping Ratio of up to 30–35 % for considerable structural drift reduction.

- Devices extensively tested and available with CE-marking.
MAURER Sliding Isolators decouple structures from seismic excitation by their sliding surface with small base shear. They remain free of wear even after ten design earthquakes whereby their lifespan matches that of the structure they are protecting.

The devices are made of a lower and upper bearing plate with a spherical MSA® sliding lens in between. The sliding liner MSM® is an extremely stress-resistant sliding material patented by MAURER and certified in the MAURER European Technical Approval ETA-06/0131.

MAURER Sliding Isolators are applied in new buildings and bridges as base isolators and bearings or adopted for the seismic retrofitting of existing structures. They can transmit extreme vertical loads, accommodate huge lateral displacements, enable rotation, and effectively re-centre the superstructure. Depending on the damping demand the isolator’s friction is reasonably adapted between 1 % and 7 % or combined with MAURER Hydraulic / Hysteretic Dampers.

**>> Classification into four types**

1. **Sliding Isolator (SI) without re-centring**
   These devices have a flat sliding plate that accommodates horizontal displacements and dissipates energy by friction between the sliding material MSM® and the stainless steel sheet.

2. **Sliding Isolation Pendulum (SIP®) with re-centring**
   These devices have a concave sliding plate, thereby working similar to a pendulum, and dissipate energy by friction on the sliding surface. The curvature of the concave plate provides the re-centring stiffness which is inversely proportional to the radius of curvature.

3. **Double Sliding Isolation Pendulum (SIP®-D) with re-centring**
   Within these isolators, the sliding lens moves between the two identical concave bearing plates, thereby doubling the displacement capacity compared to the single SIP® the diameter being equal. Conversely, the outer dimensions can be significantly reduced, the displacement capacity being equal.

4. **Adaptive Sliding Isolation Pendulum (SIP®-A) with re-centring**
   This adaptive isolator generates optimum structural isolation independent of Peak Ground Acceleration of the earthquake, reduces base shear and displacement capacity thanks to its high efficiency and ensures high rotation capability.

**>> Measured force displacement loops of Sliding Isolation Pendulums SIP®, SIP®-D and SIP®-A tested at EUCENTRE, Pavia, Italy**
Bearing Elements for Base Isolation

\( N_{sd} \) = vertical average seismic design load for required dynamic coefficient of friction
\( N_{Ed,max} \) = max. vertical earthquake load combined with \( d_{max} \)
\( d_{max} \) = total displacement for earthquake combined with service condition (thermal/wind/creep/shrinkage)

\( \text{based on assumption of 5\% dynamic friction for } N_{sd} \)
\( \text{based on assumption of 3,000 mm pendulum radius; without anchoring measures; depending on specified concrete compression stresses} \)

Sliding Isolation
Pendulum (SIP®, SIP®-D)

<table>
<thead>
<tr>
<th>( N_{sd} / N_{Ed,max} )</th>
<th>( d_{max} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>[kN]</td>
<td>[mm]</td>
</tr>
<tr>
<td>500 / 1,000</td>
<td>+/- 350</td>
</tr>
<tr>
<td>1,000 / 2,000</td>
<td>+/- 350</td>
</tr>
<tr>
<td>2,000 / 4,000</td>
<td>+/- 350</td>
</tr>
<tr>
<td>3,000 / 6,000</td>
<td>+/- 350</td>
</tr>
<tr>
<td>5,000 / 10,000</td>
<td>+/- 350</td>
</tr>
<tr>
<td>7,000 / 14,000</td>
<td>+/- 350</td>
</tr>
<tr>
<td>11,000 / 22,000</td>
<td>+/- 350</td>
</tr>
<tr>
<td>15,000 / 30,000</td>
<td>+/- 350</td>
</tr>
<tr>
<td>25,000 / 50,000</td>
<td>+/- 350</td>
</tr>
<tr>
<td>30,000 / 60,000</td>
<td>+/- 350</td>
</tr>
<tr>
<td>35,000 / 70,000</td>
<td>+/- 350</td>
</tr>
</tbody>
</table>

| SIP® | Plan view A* | Height H** |
|----------------|----------------|
| [mm] | [mm] |
| 820 | 155 |
| 880 | 165 |
| 940 | 175 |
| 990 | 185 |
| 1,085 | 190 |
| 1,160 | 200 |
| 1,260 | 215 |
| 1,360 | 240 |
| 1,560 | 295 |
| 1,620 | 325 |
| 1,710 | 365 |
| 530 | 125 |
| 580 | 135 |
| 650 | 150 |
| 710 | 165 |
| 790 | 200 |
| 860 | 230 |
| 980 | 280 |
| 1,080 | 330 |
| 1,250 | 420 |
| 1,310 | 485 |
| 1,410 | 550 |

| SIP®-D | Plan view A* | Height H** |
|----------------|----------------|
| [mm] | [mm] |

\( N_{sd} / N_{Ed,max} \) = max. vertical earthquake load combined with \( d_{max} \)
\( d_{max} \) = total displacement for earthquake combined with service condition (thermal/wind/creep/shrinkage)

**Remarks**

The dynamic coefficient of friction, the pendulum radius and the bearing displacement will be adapted individually to the structure depending on the maximum allowed base shear and displacement. Bearings can be designed for loads up to 250MN or even more.

**Main features of MAURER Sliding Isolators**

→ The design, liner material, checking and testing provisions ruled by official state approval together with CE-marking bring reliability and safety.

→ MAURER Sliding Isolators are absolutely maintenance-free allowing 50–150 years or even longer service life spans.

→ Definable isolation time period as the period of a pendulum does not depend on the vertical load.

→ After excessive static and dynamic testing on the MSM® liner material of up 50,000 m sliding path, the isolators exhibit no signs of ageing and wear what was tested at the University of California, San Diego, USA! Continued functionality is guaranteed even after ten design earthquakes, while their life span matches that of the structure itself.

→ Immediate smooth displacements without stick-slip effects as static friction values are low.
MAURER Hydraulic Dampers (MHD) can complement isolators and structural bearings to achieve a superior system behaviour in terms of reduced forces and displacements for seismic as well as service load cases. They guarantee maximum damping and controlled energy dissipation. During an earthquake, an intelligent fluid flow control system permits relative motion and keeps the response force at an almost constant level.

**Functional characteristics**

A) **Service load for temperature movements (orange area):**
No significant response forces greater than 2–5 % of \( F_d \) for velocities lower than 0.1 mm/s.

B) **Shock load (traffic, wind, earthquake; blue area):**
Sudden reaction force starting from velocity \( v_d = 0.1 \) to 2 mm/s to block impulse actions from wind and traffic while minimising structural movements resulting from these service load cases.

C) **Earthquake (grey area):**
The damper allows relative motion at high forces and thereby dissipates great amounts of energy. The maximum response force \( F_{max} \) is almost independent of velocity within the velocity range from \( v_d \) to \( 1.5 v_d \) – the so-called over velocity acc. to EN 15129. As a result, the MHD, its anchoring and the structure are protected against overloading.

**Force velocity diagram of a MHD**

- **Damper design force** \( F_{max} \) including reliability factor \( \gamma \) for 150 % over velocity and reaction tolerance due to production acc. to EN 15129.

- **Damper force reaction with force limitation independent of velocity with damping exponent** \( \alpha = 0.04 \).

**Measured force displacement diagram of a MHD with**
- \( F_{max} = 1,900 \) kN and 1,300 mm total stroke capacity tested with harmonic displacement input at Ruhr-University Bochum, Germany.

**Hydraulic Damper (MHD)**

Length of anchoring is 550 mm, variable amount depending on design forces.
**Bearing Elements for Base Isolation**

**Preliminary dimensions based on:**
- Max. velocity $v = 300$ mm/s can be adapted on demand even to 1,500 mm/s or greater
- $F_{max}$ is not significantly greater than $F_d$
- Max. internal working pressure for ultimate load case $F_{max}: 50$ MPa (500 bar)
- Frequently occurring service forces due to traffic, wind, etc.: $F_{service} = 0.5 \times F_{max}$
  - 200,000 load cycles considered $F_{service}$ with max. 25 MPa inner pressure
- Damping exponent $\alpha = 0.04$ can be adapted on demand even up to linear viscous behaviour ($\alpha = 1$) and/or even hybrid damping exponent functions achievable
- Temperature range from -40 to +40 °C
- Over velocity and manufacturing tolerances are considered acc. to EN 15129 for $F_{max}$ by the reliability factor $\gamma_v = (1 + t_d) \times 1.5 \times \alpha$ which is multiplied with designer’s force specification $F_d$

### Hydraulic Damper (MHD)

<table>
<thead>
<tr>
<th>$F_d$</th>
<th>$d_1$</th>
<th>$L_0_1$</th>
<th>$d_2$</th>
<th>$L_0_2$</th>
<th>$d_3$</th>
<th>$L_0_3$</th>
<th>$E$</th>
<th>$F$</th>
<th>$H$</th>
<th>$L_A$</th>
<th>$B_A$</th>
<th>$H_P$</th>
<th>$B_P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>[kN]</td>
<td>[±mm]</td>
<td>[mm]</td>
<td>[±mm]</td>
<td>[mm]</td>
<td>[±mm]</td>
<td>[mm]</td>
<td>[mm]</td>
<td>[mm]</td>
<td>[mm]</td>
<td>[mm]</td>
<td>[mm]</td>
<td>[mm]</td>
<td>[mm]</td>
</tr>
<tr>
<td>500</td>
<td>100</td>
<td>1,140</td>
<td>300</td>
<td>2,110</td>
<td>600</td>
<td>3,610</td>
<td>350</td>
<td>140</td>
<td>220</td>
<td>500</td>
<td>350</td>
<td>400</td>
<td>350</td>
</tr>
<tr>
<td>1,000</td>
<td>100</td>
<td>1,270</td>
<td>300</td>
<td>2,180</td>
<td>600</td>
<td>3,720</td>
<td>455</td>
<td>160</td>
<td>240</td>
<td>650</td>
<td>400</td>
<td>450</td>
<td>380</td>
</tr>
<tr>
<td>1,500</td>
<td>100</td>
<td>1,420</td>
<td>300</td>
<td>2,300</td>
<td>600</td>
<td>3,830</td>
<td>490</td>
<td>190</td>
<td>260</td>
<td>700</td>
<td>450</td>
<td>500</td>
<td>410</td>
</tr>
<tr>
<td>2,000</td>
<td>100</td>
<td>1,530</td>
<td>300</td>
<td>2,420</td>
<td>600</td>
<td>3,930</td>
<td>525</td>
<td>220</td>
<td>280</td>
<td>750</td>
<td>500</td>
<td>550</td>
<td>450</td>
</tr>
<tr>
<td>2,500</td>
<td>100</td>
<td>1,680</td>
<td>300</td>
<td>2,550</td>
<td>600</td>
<td>4,090</td>
<td>560</td>
<td>220</td>
<td>300</td>
<td>800</td>
<td>550</td>
<td>600</td>
<td>490</td>
</tr>
<tr>
<td>3,000</td>
<td>100</td>
<td>1,790</td>
<td>300</td>
<td>2,670</td>
<td>600</td>
<td>4,210</td>
<td>595</td>
<td>230</td>
<td>350</td>
<td>850</td>
<td>600</td>
<td>650</td>
<td>550</td>
</tr>
<tr>
<td>3,500</td>
<td>100</td>
<td>1,960</td>
<td>300</td>
<td>2,820</td>
<td>600</td>
<td>4,370</td>
<td>630</td>
<td>250</td>
<td>350</td>
<td>900</td>
<td>650</td>
<td>700</td>
<td>600</td>
</tr>
<tr>
<td>4,000</td>
<td>100</td>
<td>2,100</td>
<td>300</td>
<td>2,990</td>
<td>600</td>
<td>4,500</td>
<td>700</td>
<td>270</td>
<td>380</td>
<td>1,000</td>
<td>700</td>
<td>750</td>
<td>630</td>
</tr>
<tr>
<td>4,500</td>
<td>100</td>
<td>2,240</td>
<td>300</td>
<td>3,110</td>
<td>600</td>
<td>4,650</td>
<td>770</td>
<td>290</td>
<td>380</td>
<td>1,100</td>
<td>750</td>
<td>800</td>
<td>660</td>
</tr>
<tr>
<td>5,000</td>
<td>100</td>
<td>2,380</td>
<td>300</td>
<td>3,260</td>
<td>600</td>
<td>4,770</td>
<td>840</td>
<td>300</td>
<td>380</td>
<td>1,200</td>
<td>800</td>
<td>850</td>
<td>700</td>
</tr>
<tr>
<td>5,500</td>
<td>100</td>
<td>2,510</td>
<td>300</td>
<td>3,420</td>
<td>600</td>
<td>4,910</td>
<td>910</td>
<td>320</td>
<td>390</td>
<td>1,300</td>
<td>850</td>
<td>900</td>
<td>750</td>
</tr>
<tr>
<td>6,000</td>
<td>100</td>
<td>2,660</td>
<td>300</td>
<td>3,520</td>
<td>600</td>
<td>5,050</td>
<td>980</td>
<td>330</td>
<td>390</td>
<td>1,400</td>
<td>900</td>
<td>950</td>
<td>800</td>
</tr>
<tr>
<td>6,500</td>
<td>100</td>
<td>2,790</td>
<td>300</td>
<td>3,640</td>
<td>600</td>
<td>5,160</td>
<td>1,050</td>
<td>340</td>
<td>400</td>
<td>1,500</td>
<td>950</td>
<td>1,000</td>
<td>830</td>
</tr>
<tr>
<td>7,000</td>
<td>100</td>
<td>2,940</td>
<td>300</td>
<td>3,840</td>
<td>600</td>
<td>5,350</td>
<td>1,120</td>
<td>350</td>
<td>400</td>
<td>1,600</td>
<td>1,000</td>
<td>1,050</td>
<td>860</td>
</tr>
<tr>
<td>7,500</td>
<td>100</td>
<td>3,070</td>
<td>300</td>
<td>3,940</td>
<td>600</td>
<td>5,490</td>
<td>1,190</td>
<td>360</td>
<td>420</td>
<td>1,700</td>
<td>1,050</td>
<td>1,100</td>
<td>900</td>
</tr>
<tr>
<td>8,000</td>
<td>100</td>
<td>3,230</td>
<td>300</td>
<td>4,100</td>
<td>600</td>
<td>5,670</td>
<td>1,260</td>
<td>380</td>
<td>430</td>
<td>1,800</td>
<td>1,100</td>
<td>1,150</td>
<td>950</td>
</tr>
</tbody>
</table>

$F_d$ = design force value for the ULS load case without reliability factor $\gamma_v$ of 150 % on velocity.

$d_1$, $d_2$, $d_3$ = various displacement assumptions with correlating damper dimensions.

---

**Key Characteristics of MAURER Hydraulic Dampers MHD**

- No leaking effects due to the triple-seal-guide system avoiding wear and fatigue.
- Protection of device and structure by effective force limiter function with special valve system: $F_{max}$ is not far bigger than $F_d$ as $\gamma_v$ will be in the range of 1.07 to 1.12 only, including production tolerances ($t_d$) of 0.05 – 0.10.
- Smaller displacements and forces within the system with damping exponents $\alpha = 0.04$ to 1.0. Hybrid systems consisting of various exponents for the associated velocity ranges are possible.
- Immediate lock-up after max. 1–3 mm displacement for service loads resulting from low compressibility (only 0.5 to 3 %) of the hydraulic oil.
- Optimum performance in any climate zone. Functional characteristics virtually independent of temperature within -40 to +40 °C.
- Optimized design with CE-marking which is absolutely maintenance-free.
- No long term leaking in its resting state as the MHD is not pre-stressed and is not under any significant pressure.
- MAURER can provide semi-active dampers especially adapted to the needs of stay cables and tuned mass dampers.
MAURER Seismic Joints

All expansion joints in road and railway bridges are used to accommodate movements and rotations between the adjacent structures while simultaneously transferring traffic loads and forces. They must be designed to handle multiple degrees-of-freedom movements provided by the structural bearing system as well as service, extreme limit state and seismic load conditions. Key influencing parameters for service movements are temperature fluctuations, creep/shrinkage of the concrete and imposed loads such as wind and traffic. Seismic effects generate additional, in some cases significant, deflections and displacements that often deviate considerably in terms of intensity, direction and velocity from the service condition. During a seismic event it is essential that joint systems remain structurally stable and after a seismic event they should be fully operable or must at least enable restricted traffic for security and rescue services.

>> Key Benefits of MAURER Seismic Expansion Joints

- Emergency vehicles can immediately pass over the joints after a seismic event
- Depending on the project specification requirements, the amount of damage caused by large seismic displacements is variable – no damage or limited damage while immediate overpassing of the joint for emergency vehicles is usually always a MUST
- Fuse Box-Systems provide a more economical design combined with quick repair procedures
- Service life of 20-50 years or more is possible due to fatigue resistant design and incorporation of durable materials and details.

>> Swivel Joist Expansion Joint for Road Bridges

MAURER Swivel Joist Expansion Joints are particularly suited for large and complex structural movements. Due to the freedom of movement of each individual lamella, total movements of the expansion joint in longitudinal direction of 3.5 m or more can be accommodated without damage during the earthquake. By controlling each individual lamella separately, very large longitudinal service movements can be accommodated at the same time as lateral bridge movements of up to ± 2.5 m.

Various movement combinations which can be accommodated by a MAURER Seismic Swivel Joist Expansion Joint are illustrated below while looking down onto the joint:
Seismic Joints

> Fuse Box Systems for modular joints

In situations where it is decided to not accommodate all of the seismic displacement by the lamellas of the Swivel Joint or any other modular expansion joint type, the MAURER Fuse Box System should be considered. The Fuse Box System is designed to allow seismic movements from smaller earthquakes while accepting limited damage to the joint system if this displacement is exceeded in a larger earthquake. The concept behind the Maurer Fuse Box System is to protect the bridge deck from high compressive stresses and damage when the bridge structure closes more than the space available in the gaps between the lamellas.

In general two MAURER Fuse Box Systems are available:

> Longitudinal Fuse Box System

Type I/II/II:
For the design of the longitudinal fuse box system it is important to know the maximum opening and closing movements of the expansion joint. For large seismic joint opening movements the gaps between lamella may open to more than 150 mm. For large seismic closing movements resulting no gaps between lamella the longitudinal fuse box system will be released to prevent the expansion joint from being crushed between the bridge deck and abutment or transition pier.

Type I and II:
An angled steel plate is used to guide the joint support box assemblies upwards when the joint closes beyond the minimum joint opening. The fuse mechanism is activated by intentionally failing welded connections at specific locations.

Type III:
One side of the entire joint drops down vertically into a prepared space within the fuse box and then slides when the joint closes beyond the minimum joint opening. The fuse mechanism is activated by intentionally failing bolted connections near the roadway surface and at the lower portion of the joint where it connects to the structure.

Type IV:
A sliding rail-guide system on one side of the joint is released by failing a notched steel pin when lateral bridge movements in either direction exceed the design service movement capacity. The sliding guide fuse prevents the joint from exceeding the lateral movement capacity which would cause lamella to lose support and collapse and also avoids damage to the support beams.

The MAURER Fuse Box System protects the bridge deck from excessive stresses and destruction. The activated Fuse Box can ensure the safety for passing rescue services. Fast and simple repair of the expansion joint and adjacent bridge deck, i.e. small welds, bolted connections and asphalt repair work, is possible.
Available Seismic Expansion Joint types with and without Fuse Box Systems:

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Railway</th>
<th>Roadway</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Guided Cross-Tie</td>
<td>Swivel Joist Expansion Joint without Fuse Box</td>
</tr>
<tr>
<td>Before earthquake</td>
<td>Unchanged condition after earthquake</td>
<td>Type I</td>
</tr>
<tr>
<td>After earthquake</td>
<td>Unchanged condition after earthquake</td>
<td>Type I</td>
</tr>
<tr>
<td>Traffic safety during earthquake</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>Condition after DBE</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>Condition after MCE</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>Passing over of rescue service</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>after earthquake DBE, MCE</td>
<td>++++</td>
<td>++++</td>
</tr>
</tbody>
</table>

15 Temmuz Şehitler Köprüsü, Turkey

Type I Fuse Box System
**Guided Cross-Tie for railway bridges**

In railroad bridges, movements occurring between superstructure and abutment lead to additional track tension and stresses on the rail anchorage. With the Guided Cross-Tie expansion joint a bridging system has been developed which ensures that the sleeper spacing does not exceed the permissible value while accommodating all structural movements (displacement in X-, Y- and Z-direction; torsion; twisting) without causing any damage within the joint. The control principle of the well proven roadway Swivel Joist Expansion Joint was successfully adapted to fulfil all requirements for railroad traffic too! The Guided Cross-Tie is positioned in the joint recess prepared on site and monolithically connected to the structure by a concrete closure pour.

![Railway line from Mexico City to Toluca, Mexico](image)

**Key benefits of MAURER Guided Cross-Tie:**

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accommodates three directional dimensional seismic movements without damage</td>
<td>Accommodates three directional dimensional seismic movements without damage.</td>
</tr>
<tr>
<td>Effective derail protection mechanism can be integrated when required</td>
<td>Effective derail protection mechanism can be integrated when required.</td>
</tr>
<tr>
<td>Design for longitudinal service and seismic movements of 1600 mm or more</td>
<td>Design for longitudinal service and seismic movements of 1600 mm or more.</td>
</tr>
<tr>
<td>Designs available for light rail, regular rail or cargo rail systems</td>
<td>Designs available for light rail, regular rail or cargo rail systems.</td>
</tr>
<tr>
<td>Can accommodate axle loads up to 250 kN and overpassing velocities of 300 km/h or more depending on design requirements</td>
<td>Can accommodate axle loads up to 250 kN and overpassing velocities of 300 km/h or more depending on design requirements.</td>
</tr>
<tr>
<td>Service life of 20 years or longer due to fatigue-free design and durable watertight sleeper seals. No planned regular maintenance works.</td>
<td>Service life of 20 years or longer due to fatigue-free design and durable watertight sleeper seals. No planned regular maintenance works.</td>
</tr>
<tr>
<td>Excellent travel comfort for overpassing train traffic</td>
<td>Excellent travel comfort for overpassing train traffic.</td>
</tr>
<tr>
<td>Quick and easy installation within 1-2 days</td>
<td>Quick and easy installation within 1-2 days.</td>
</tr>
<tr>
<td>Easy and quick inspection without interrupting train traffic. Inspection and any maintenance work can be done from below the joint.</td>
<td>Easy and quick inspection without interrupting train traffic. Inspection and any maintenance work can be done from below the joint.</td>
</tr>
</tbody>
</table>
MAURER systems withstand not only every earthquake, but also the world’s toughest certification processes.

The components for earthquake protection are measured and tested according to EN 1337, EN 15129, AASHTO or any other preferred standards on an individual, project-related basis.

The European standards ensure the CE mark and certify conformity. Third-party monitoring is required, e.g. by the Materials Testing Institute (MPA) of the University of Stuttgart or other certified, independent institutions.

The tests of the earthquake devices have already been carried out at the University of the Federal Armed Forces in Munich / Germany, the Ruhr - University in Bochum / Germany, the EU Centre at the University of Pavia / Italy and the ISMES Institute in Bergamo / Italy, the Politecnico di Milano / Italy, the University of California in San Diego / USA and the University of California in Berkeley / USA.

---

**MAURER type plate**

- 1. Storage type
- 2. Job number and year
- 3. Page number
- 4. Displacement
- 5. Presetting
- 6. Set of Rules Standard 1
- 7. Set of Rules Standard 2
- 8. Installation location
- 9. Presetting
- 10. Presetting

---
Excerpt from certificates and European Technical Approvals for:

MAURER MSM® Spherical and Cylindrical Bearings ............ European Technical Approval ETA-06/0131 DIBT

MAURER MSM® Spherical and Cylindrical Bearings ............ EC Certificate of Conformity MPA Stuttgart 0682-CPD-005.2

MAURER Elastomer Bearings ........................................ EC Certificate of Conformity MPA Stuttgart 0672-CPD-005.5

MAURER Sliding Pendulum Bearings Type SIP® .............. EC Certificate of Conformity MPA Stuttgart 0672-CPD-005.102

MAURER Hydraulic Dampers (MHD) ...................... EC Certificate of Conformity MPA Stuttgart 0672-CPD-005.101

MAURER Lead Core Bearings (MLRB) .................. Certificate of Constancy of Performance 0672-CPR-0362
Individually adapted testing of seismic devices

On request MAURER will do static and dynamic testing on any seismic device according to the required standards. It is important to test not only for ultimate seismic load cases but also, if relevant, for the structure, consider frequently occurring service load cases (wind, braking of railway, traffic loading vibrations, etc.).

The seismic testing is finally confirming the capability of energy dissipation with its upper and lower bounds, the stiffness, the stability and integrity of the device, and the durability that even after more than five design earthquakes MAURER devices do not suffer of any damages.

The aim of testing for service load condition is more related to the proof of wear resistance (10,000 m sliding test for thermal or traffic displacements), fatigue resistance (up to several million load cycles of wind loading), initial high stiffness resistance to lock-up for service impact loadings (railway, wind, etc.) and general durability.

>> Atomic Power Plants and Wind Parks/Europe
Tests at University of Armed Forces Munich/Germany of structural rubber isolators for 900 kN to 6,590 kN service load capacity, lateral up to +/- 120 mm and 2 mm to 15 mm vertical displacement with 0.04 Hz to 1 Hz.

>> Incheon Airport Project/Korea
Test at EU Center University Pavia/Italy of SIP® pendulum isolator for 35,000 kN load capacity, +/- 200 mm displacement and 0.175 Hz for seismic application in an access bridge.

>> Russkiy Bridge Project
Test at CALTRANS University of California San Diego/USA of MHD damper for 3,000 kN service and up to 5,000 kN ultimate force, 800 mm stroke, -40 °C and up to 750 mm/s as the application is for service wind and ultimate seismic load conditions with low temperature requirement.

>> Axios Railway Bridge Project/Greece
Test at Ruhr-University Bochum/Germany of MLRB lead rubber bearing for 22,000 kN load capacity, +/- 260 mm displacement and 250 mm lead core diameter inside for great energy dissipation capacity during seismic load conditions.
No two structures are the same – nor any MAURER system

>> Russkiy Bridge in Vladivostok / Russia

Task: Structural protection against wind and earthquakes on what is currently the widest spanning cable-stayed bridge in the world with a pylon distance of 1,104 m.

Scope of the project: Swivel-Joist Expansion Joints of 2.4 m movement and slip security (XLS 2400), MAURER MSM® spherical (KGA; KGE) and horizontal force bearings with 34 MN superimposed load, plus 25 MN horizontal force, hydraulic wind/earthquake dampers (MHD) for 3 MN and 2.2 m of movement, passive and adaptive cable-stayed dampers for up to 578 m long cables.

>> Las Piedras railway viaduct to the north of Malaga / Spain

Task: The Spanish high-speed train AVE generates very high braking forces in the 1,200-metre long viaduct, but these must not be allowed to cause any significant structural movements. In addition, the up to 93-metre tall and flexible pillars are subjected to considerable stress during earthquakes of 0.1 g.

Scope of the project: MAURER MSM® Spherical Sliding Bearings (KGA, KGE KF) for up to 25 MN of superimposed load, 2 MN of horizontal force and +/- 350 mm of movement. Hydraulic Dampers (MHD) for 2.5 MN, plus +/- 350 mm of movement with shock transmitters and load limiter function (MSTL) for brake loads.

>> New Acropolis Museum in Athens / Greece

Task: Structural isolation to protect against earthquakes for a 33,000 tonne new building.

Scope of the project: MAURER MSM® Sliding Pendulum Bearings with an upper Sliding Plate (SIP®-S) for up to 13.6 MN of superimposed load and +/- 255 mm of movement.
>> Djamaâ El Djażîr Mosque in Algiers/Algeria

Task: The maximum earthquake acceleration on the 145-metre long, 145-metre wide and 65-metre tall main building is around 0.65 g due to the safety constructions and weight of the structure. Even at this acceleration, the structure and its contents must not sustain any significant damage.

Scope of the project: MAURER MSM® Sliding Pendulum bearings with two Sliding Plates and Rotational Joint (SIP®-DR) for up to 27 MN and +/- 655 mm of movement; Hydraulic Dampers (MHD) for 2.5 MN, plus +/- 655 mm of movement.

>> Nissibi Bridge / Turkey

Task: The 610-metre long bridge is to be placed on elastic/floating bearings for service and earthquake states. The temperature fluctuations must also be distributed evenly across the structure and the maximum movement amplitudes limited in the event of an earthquake.

Scope of the project: MAURER Lead Core Elastomer Bearings (MLRB) for up to 31 MN of superimposed load and +/- 380 mm of movement.

>> SOCAR Tower in Baku/Azerbaijan

Task: The headquarters of the State Oil Company of Azerbaijan (OSCAR) is 200 m tall and symbolises the shape of a flame. As a result of its elastic, flexible construction, significant structural accelerations can occur on the upper storeys in certain wind loads and in the event of earthquakes that cause discomfort for the building’s inhabitants.

Scope of the project: MAURER Mass Pendulum Damper (MTMD-P) with a 450-tonne pendulum mass including Hydraulic Damper (MHD) for the damping of 0.16 – 0.32 Hz in the X and Y direction and +/- 400 mm of movement in all horizontal directions. As the end stops, four Lead Core Bearings (MLRB) were provided for the 450-tonne mass block; a monitoring system for movement and acceleration was included.
Franjo Tudjman Bridge near Dubrovnik/Croatia

Task: The 518-metre-long stayed-cable bridge lies in an earthquake zone of moderate intensity. As a result, the flat sliding bearings need to be designed for larger movements in a lateral direction and be designed to transfer lifting forces. The bridge deck movements in a longitudinal direction are reduced through hydraulic dampers to +/- 150 mm in an earthquake load situation. The abutments are fitted with Swivel-Joist Expansion Joints that can absorb the required horizontal and vertical movements.

Scope of the project: MAURER Traction-Compression Pot Bearings (TGA-Z) with a load capacity of 975 t; Hydraulic Dampers (MHD) with 2,000 kN and 500 mm of total movement; Swivel-Joist Expansion Joint DS 560 F; 40-150 kN cable - stayed dampers.

Harilaos Trikoupis Bridge near Patras/Greece

Task: The 2,250-metre long bridge deck needs to compensate enormous movement amplitudes from temperature fluctuations and earthquakes at the abutments. The foreshore ramps need to be supported with elastic floating bearings.

Scope of the project: MAURER Swivel-Joist Expansion Joints DS 2480 F; Elastomer Bearings with a 3,100 kN load capacity.

Donau City Tower in Vienna/Austria

Task: The 220-metre tall building vibrates in high winds and earthquakes. The accelerations for a wide range of loads and frequency fluctuations are to be reduced to provide adequate comfort. To do this, a 300-tonne pendulum mass is used in a mass pendulum damper.

Scope of the project: MAURER Semi-Active Hydraulic Dampers (MRD) for 30-80 kN and +/- 700 mm of movement to dampen the 300-tonne mass pendulum; monitoring system for movement, force and acceleration included.