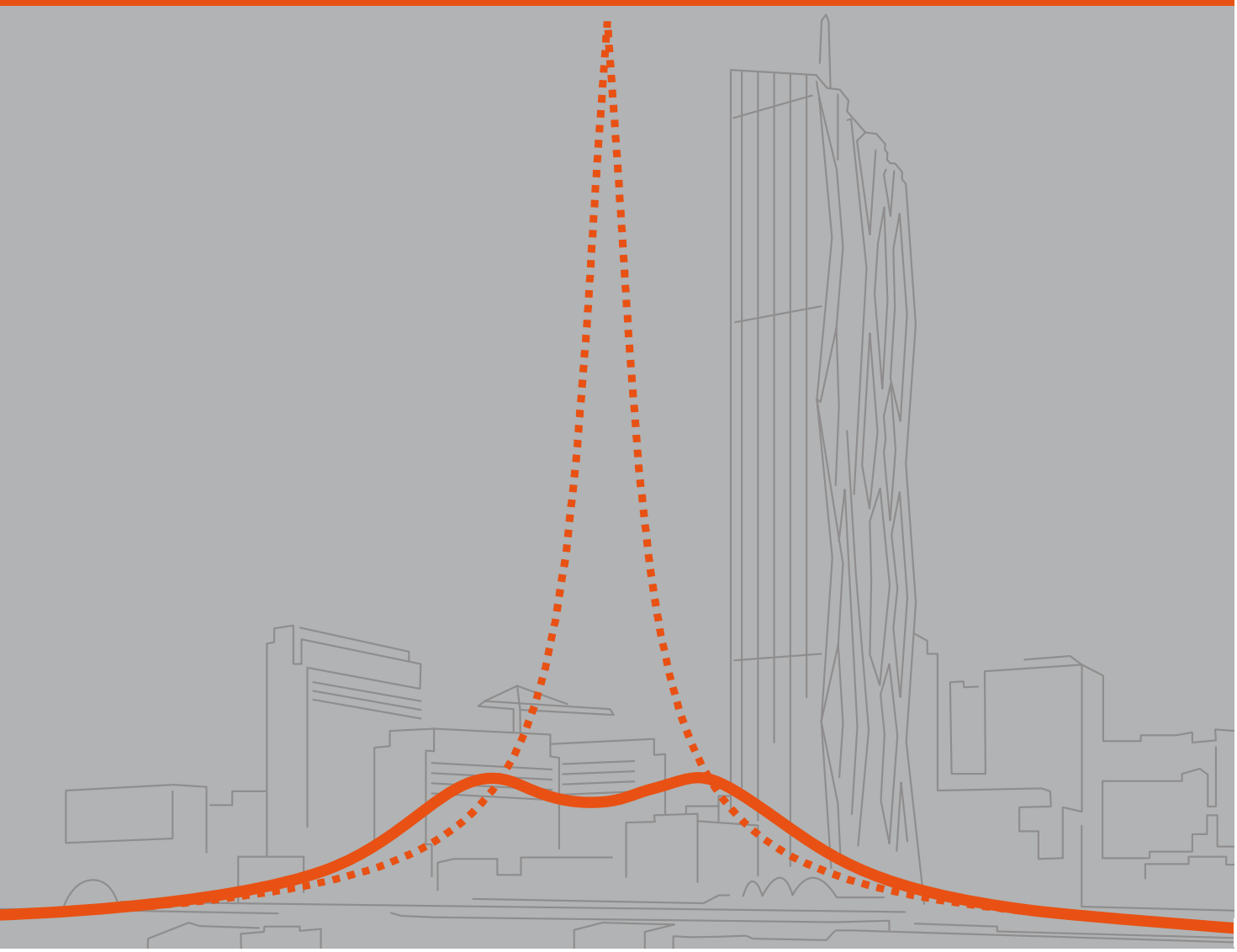
MAURER

Vibration Control of Tall Buildings

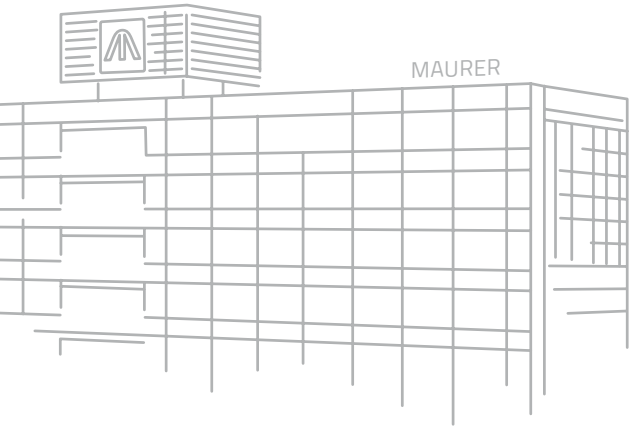
MAURER Tuned Mass Dampers



forces in motion

Experience in motion control

The MAURER Group is a leading specialist in mechanical engineering and steel construction and has been family-owned since it was formed back in1876. The MAURER Group is currently one of the global technological leaders in steel and plant constructions in various specialist fields. We offer products and solutions which are particularly notable for their quality, durability and reliability.



Our fields of expertise are customised structural protection systems


EXPANSION JOINTS


STRUCTURAL BEARINGS


TUNED MASS DAMPERS

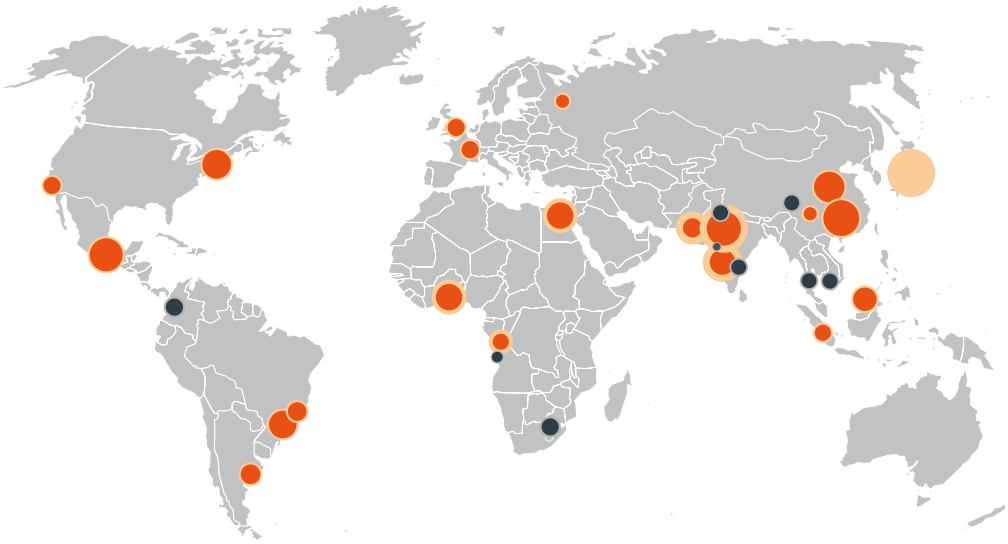

ANTI-SEISMIC DEVICES

An important part of our activities is monitoring climatic, seismic and traffic-induced forces and movements, which have an impact on buildings, bridges and complex dynamic structures. These effects can be controlled through the selective use of our expansion joints, structural bearings, tuned mass dampers and anti-seismic devices to protect the structures from damage.

Megacities of tomorrow will grow in population, infrastructure and height

Due to the urbanisation of the world's population, which in some cases is occurring at rapid speed, politicians, city planners and transport system developers are facing new challenges. For many academics, the solution for the city of tomorrow lies in its compactness. "Buildings better connected, more compact cities based on mass public transport can save over $3 trillion in investment costs over the next 15 years. These measures will improve economic performance and reduce emissions, raising the quality of life." New Climate Economy Report

Short distances are the key. The creation of a vertical village in the city: apartment blocks are being stacked on top of one another rather than being built side-by-side, with roof gardens, playgrounds and courtyards included in the development.

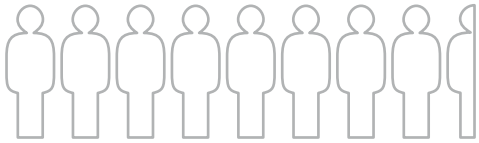


CURRENT MEGACITIES

FUTURE MEGACITIES*

POPULATION IN 2030*

8.5 BILLION



* Source: World Urbanization Prospects: The 2014 Revision, London

MAURER Tuned Mass
to efficiently solve vib

The challenge

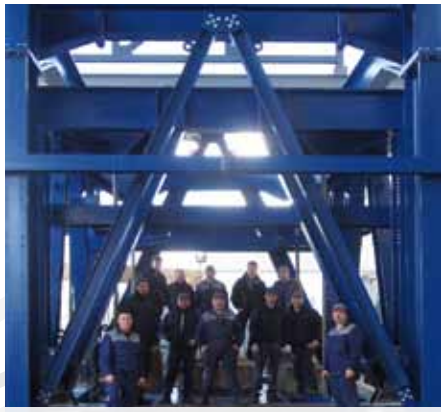
Civil engineering structures may be prone to large amplitude vibrations due to wind and earthquake loading mechanisms because of their slenderness and low inherent damping ratio of approx. 1%. Without additional damping measures the following problems may arise:

- Wind loading mechanisms may evoke resonance and therefore large amplitude oscillations in high-rise buildings, which dramatically reduce the comfort (sea-sickness) and therefore limit the use of the building.
- Free vibrations of tall buildings after earthquake excitation may cause low cycle fatigue.
- Bending and torsional galloping and flatter vibrations in bridges lead to large amplitude and therefore dangerous resonant vibrations (Volgograd Bridge) that may even destroy the deck structure (Tacoma Narrows Bridge).
- Human-induced vibrations in stadiums, floors, and footbridges may yield vibration amplitudes that are beyond the acceptable maximum values (Millennium Bridge).

Dampers – designed
ration problems

The MAURER solution

MAURER offers different types of tuned mass dampers (TMD) with up to 1,000 tonnes of tuned mass to optimally solve the vibration problem:



MAURER FOLDED PENDULUM DAMPER INSTALLATION TEAM, SOCAR TOWER, BAKU

>> **Passive tuned mass dampers:**

- **standardTMDs**: TMDs constructed with springs for the mitigation of vertical and horizontal oscillations of bridges, stadiums and floors, and TMDs designed in pendulum form for the mitigation of horizontal vibrations of slender structures.
- **foldedTMDs:** TMDs constructed by two folded pendulums in order to significantly reduce the required vertical space in high-rise buildings.
- **compactTMDs:** pendulum TMDs with additional inverted pendulum for minimum required vertical space in super tall buildings.

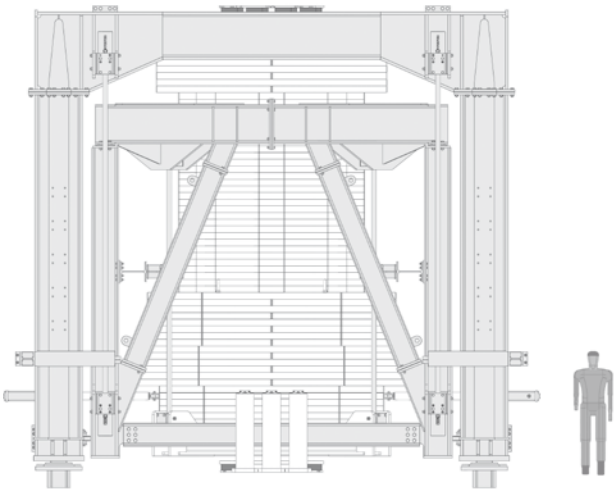
>> **Adaptive tuned mass dampers:**

- **controlledTMDs:** real-time frequency and damping controls according to the actual frequency of vibration, whereby the vibration reduction is enhanced or the mass ratio can be reduced.

The key features of Tuned Mass Dampe

Benefits of MAURER TMDs

- The different mass damper types guarantee the best solution to the vibration problem.
- Model-based optimal design of all mass damper types by MAURER as a service.
- Vibration measurement on the structure by MAURER.
- Quality control by measurement of TMD properties in the workshop and installed in the structure.
- MAURER TMDs are robust, maintenance-free and long-lasting (>20 years) due to their optimal design, precise manufacturing process and quality controls.



DRAWING FOLDED PENDULUM DAMPER
SOCAR TOWER, BAKU

>> **Specific benefits of MAURER TMDs**

- **standardTMDs:** cost efficient
- **foldedTMDs & compactTMDs:**

  // significant cost reduction in high-rise buildings due to minimised height of these TMD types

  // optimal frequency tuning in both main directions due to innovative cable fixation tunings

- **controlledTMDs:**

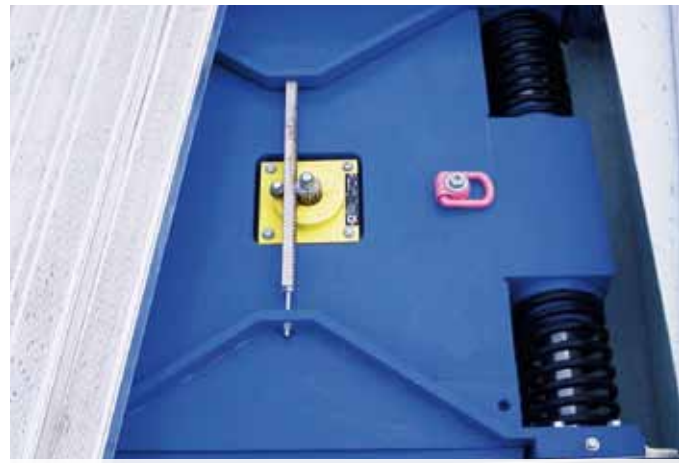
  // maximum comfort in buildings through improved vibration reduction of up to 80 % compared to passive TMDs

  // same vibration reduction as with passive TMDs but with reduced tuned mass (75 % to 85 % of nominal tuned mass)

  // monitoring of structural vibrations included

MAURER
rs

CONTROLLED VERTICAL TMD



STANDARD HORIZONTAL TMD

FOLDED PENDULUM TMD

STANDARD VERTICAL TMD

Resilient structures in a fast-moving world

>> SOCAR Tower in Baku | Azerbaijan

Task: Mitigation of fundamental bending modes in both main directions with different eigenfrequencies

Scope of project:

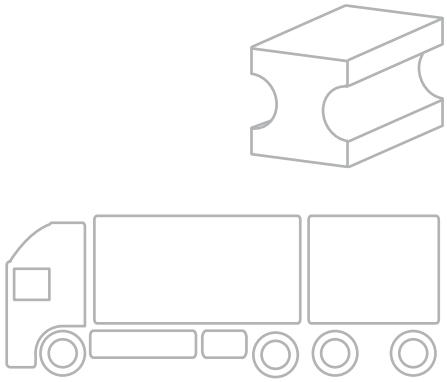
- The total height of the folded pendulum including the steel frame construction, cable clamping devices and lead rubber bearings could be reduced from approx. 11 m of the conventional pendulum TMD to approx. 7 m of the foldedTMD.
- The damper mass of 450 tonnes of the foldedTMD corresponds to the mass ratio of 4.5 %.
- The steel frame construction of the foldedTMD and the passive oil dampers are designed to accommodate damper relative motion amplitudes of up to ± 480 mm.
- In operation

>> Danube City Tower in Vienna | Austria

Task: Controlled mitigation of first bending mode within the frequency range of 0.17 Hz to 0.21 Hz

Scope of project:

- The control force range of both real-time controlled semi-active dampers is given by the residual force of approx. 3 kN and the maximum force of approx. 90 kN.
- The tuned mass of 300 tonnes corresponds to the mass ratio of 0.75 %.
- The adaptive damping control approach of the controlledTMD increases the damping disproportionately for damper relative motion amplitudes greater than ± 0.6 m in order to avoid non-acceptable large damper relative motion amplitudes; additionally, shock impact dampers are installed.
- In operation



280 TONNES OF STEEL
= 7 FULLY LOADED
SEMI-TRAILERS

>> Alphabetic Tower in Batumi | Georgia

Task: Mitigation of wind-induced vibrations in both main directions

Scope of project:

- The standardTMD in pendulum form is optimally tuned to the eigenfrequency of 0.498 Hz in both main directions of the Alphabetic Tower in Batumi.
- The damper mass of 62.85 tonnes of the standardTMD corresponds to the mass ratio of 3.5 %.
- The joints and lengths of the pendulum rods and the cylindrical oil dampers are designed for the maximum damper relative motion amplitude of ± 0.24 m.
- In operation

>> Marina Bay Sand Hotel | Singapore

Task: Reducing the vertical vibrations of the cantilevered part due to wind and human-induced excitation

Scope of project:

- At a height of 200 m, these towers have been given a roof structure that consists of a garden with an area of 1 hectare, including a 150 m long pool and 250 trees.
- The garden is supported by 17 spherical bearings to allow for its required horizontal movement.
- A tuned mass damper system with 5,000 kg of tuned mass reduces the vertical vibrations of the cantilevered part of the garden.
- In operation

IN TIME
IN BUDGET

>> Olympic Flame Monument in Sochi | Russia

Task: To dampen the vibration of a 45 m tall torch in the Sochi Olympic Park at the windy coast of the Black Sea

Scope of project:

- Each of the three dampers weighs one tonne, 750 kg of which damper mass.
- The natural frequencies of the standardTMDs can be optimally adjusted to the broad frequency range of 0.46 Hz to 1.55 Hz by the unique design of these standardTMDs that allows adding, removing or exchanging the coil springs on site.
- The standardTMDs are designed to accommodate the relative motion amplitude of +/- 70 mm.
- In operation

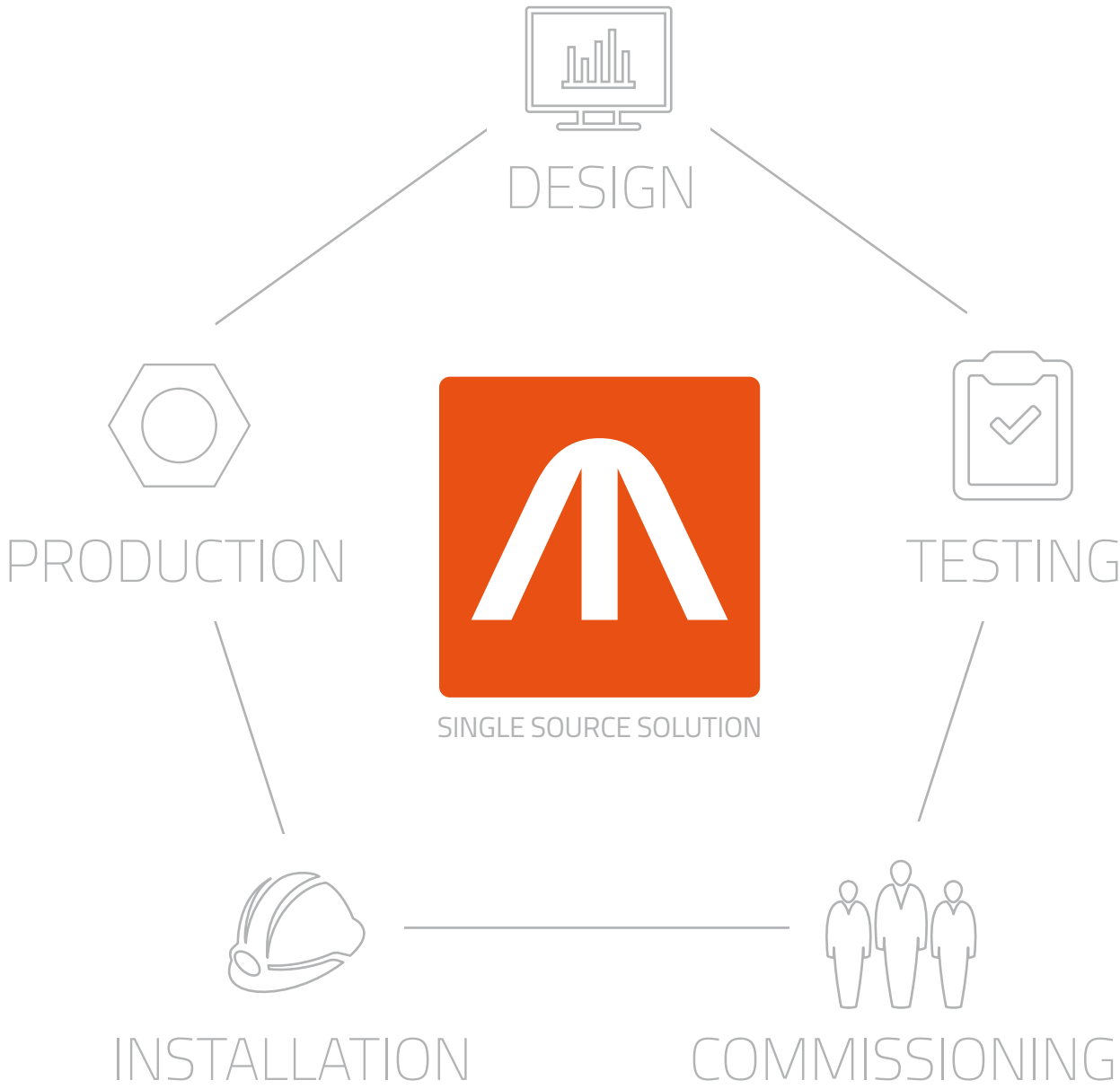
>> AlpSpix in Garmisch-Partenkirchen | Germany

Task: The vibration of the viewing platform needed to be reduced to a sensitive comfort level for visitors.

Scope of project:

- The four tuned mass dampers with a total weight of 340 kg each have the shape of flat square boxes with a footprint of 650 x 650 mm.
- The oscillating damper masses of 150 kg each are divided into several steel plates so that they can be adjusted retroactively.
- In operation

Quality and services for you



>> We also offer the following services:

- Construction services
- Installation supervision
- Inspection
- Maintenance
- Refurbishments
- Static & dynamic analyses
- Component testing
- Design planning
- Monitoring
- Research and development
- Training courses

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