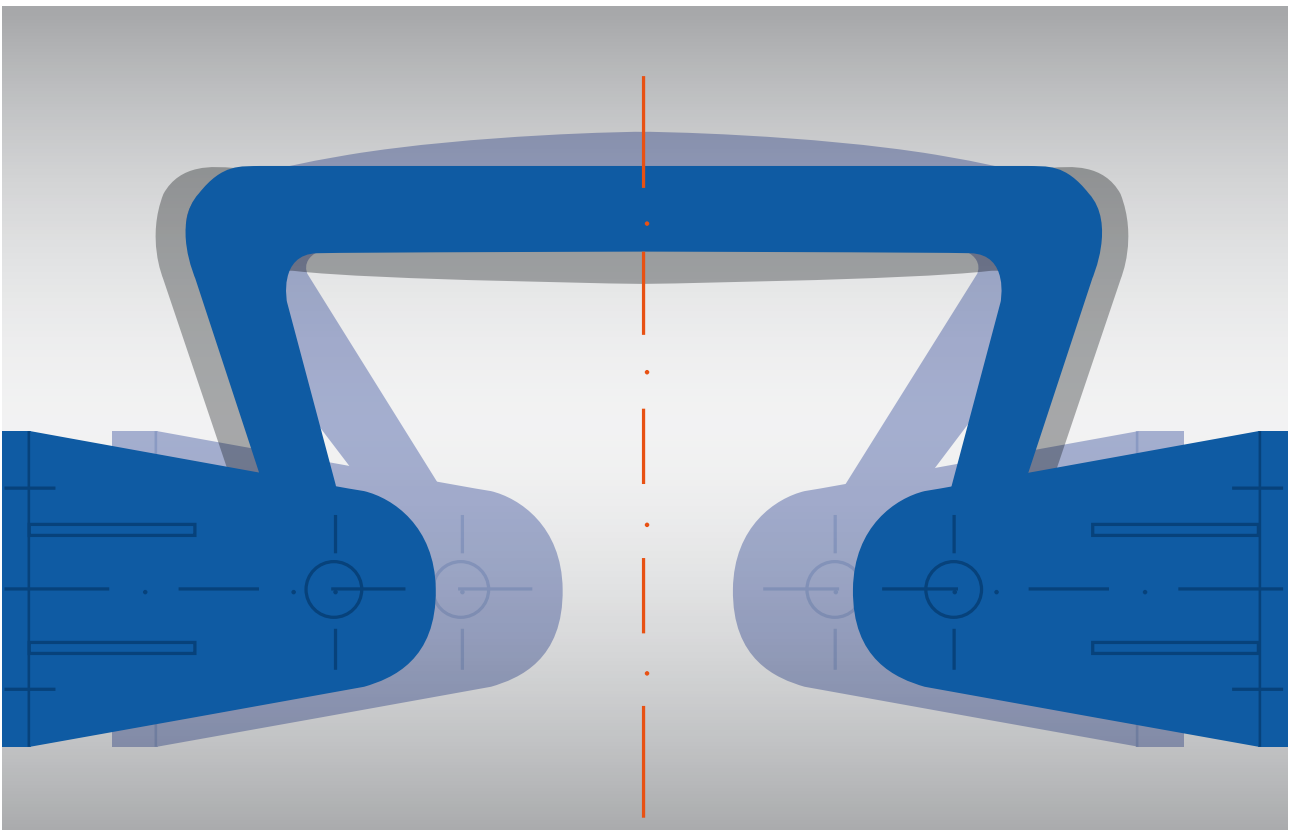


MAURER MANTIS®
Long-Stroke Hysteretic Damper 



MAURER MANTIS®

Application within Seismic Isolation Systems

The MANTIS® is a highly effective and durable long-stroke hysteretic damper for seismic protection of small to mid-size multi-span bridges (Fig. 1) or for other structures with relative movements up to ± 410 mm or larger. The relative lateral and/or longitudinal seismic displacements between the deck and abutments will be reduced and limited by the effective damping and stiffness provided by this device. To dissipate the seismic energy, the damper is fixed to the structure with connection pins and support brackets (Fig. 2). It is particularly suitable for structures experiencing not more than ± 3 mm to ± 9 mm of frequent service (e.g. thermal) movements at the location of the devices. Therefore the optimal installation location of the device for longitudinal displacements is the bridge centre span or the abutment for shorter bridges. In lateral bridge direction the MANTIS® can be even placed on any axis. Frequent service loads will be transmitted within the elastic range of the device and the fatigue behaviour can be checked according to EN1993-1-9 or other standards.

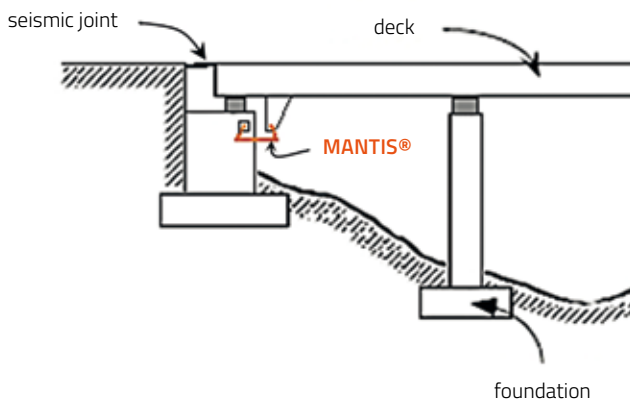


Fig. 1: Typical location of MANTIS® devices within bridge structures



Fig. 2: Components of a MANTIS® device

The MANTIS® is a bilinear hysteretic damper made of none ageing and none wearing components allowing resilient and durable performance. Due to its optimized shape and high energy dissipation capacity a perfectly symmetric force-displacement response under tension/compression loads is achieved. According to EN15129 the device is classified as a Displacement Dependent Device (DDD) and a Non-Linear Device (NLD). The re-centering capacity within the applied structural systems must be checked according to applicable standards. In case the re-centering capability is not sufficient, an isolation or spring system (e.g. elastomeric or sliding pendulum isolators) with adequate re-centering capacity should be applied in parallel.

Key benefits of MANTIS®

- Excellent displacement reduction due to high efficiency and performance reliability, i.e. large energy dissipation capability
- Long service life of 100 years or more without any maintenance
- After shock functionality provided since 2-4 MCE events can be accommodated without damage or failure
- Effective & smooth perfectly symmetric seismic performance under compression and tension loading
- Simple bilinear model suitable for easy analysis
- Easy visual inspection and function check after earthquake events
- CE-marking and certification available upon request
- Modular serial or parallel arrangement of devices possible to achieve the required energy dissipation

Sizes and performance data

Operation temperature range: -30°C to +80°C

The maximum displacement capability is calculated according to EN15129 and EN1998-2 considering reliability factors of $\gamma_x=1,1$ and $\gamma_b=1,5$ on top of seismic design displacement d_{bd} :

$$d_{max} = d_{cd} = \gamma_x \cdot \gamma_b \cdot d_{bd}$$

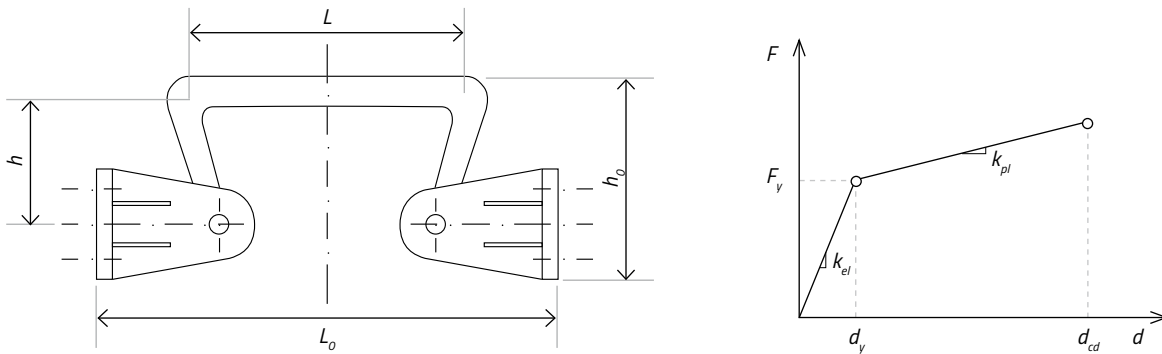


Fig. 3: Outline dimensions and function performance of a MANTIS® device

Seismic design displacement $d_{bd} = \pm 125 \text{ mm}$, $d_{max} = \pm 200 \text{ mm}$			1	2	3	4
Design force	F_{bd}	[kN]	250	500	1000	2000
Yielding force	F_y	[kN]	230	450	860	1690
Elastic stiffness	k_{el}	[kN/mm]	30	60	145	285
Plastic stiffness	k_{pl}	[kN/mm]	0,3	0,6	1,5	2,7
Displacement capacity	$d_{max} = d_{cd}$	[±mm]	200			
SLS displacement	$d_{SLS} = d_y$	[±mm]	3,5	3,5	3,0	3,0
Length in mid. position	L	[mm]	600	650	750	1050
Height	h	[mm]	550			
Assembly length	L_0	[mm]	≈L + 600			
Assembly height	h_0	[mm]	≈L + 300			

Seismic design displacement $d_{bd} = \pm 250 \text{ mm}$, $d_{max} = \pm 410 \text{ mm}$			1	2	3	4
Design force	F_{bd}	[kN]	250	500	1000	2000
Yielding force	F_y	[kN]	235	450	900	1800
Elastic stiffness	k_{el}	[kN/mm]	12	25	75	150
Plastic stiffness	k_{pl}	[kN/mm]	0,1	0,2	0,5	0,8
Displacement capacity	$d_{max} = d_{cd}$	[±mm]	410			
SLS displacement	$d_{SLS} = d_y$	[±mm]	9	9	6	6
Length in mid. position	L	[mm]	1300	1300	1300	1800
Height	h	[mm]	550			
Assembly length	L_0	[mm]	≈L + 600			
Assembly height	h_0	[mm]	≈L + 300			

The performance parameters may vary and are dependent on final structural requirements. Custom design for project specific displacement and force levels is possible.

Performance testing

Successful and extensive third party testing to get CE certification was performed at EUCENTRE in Pavia, Italy.

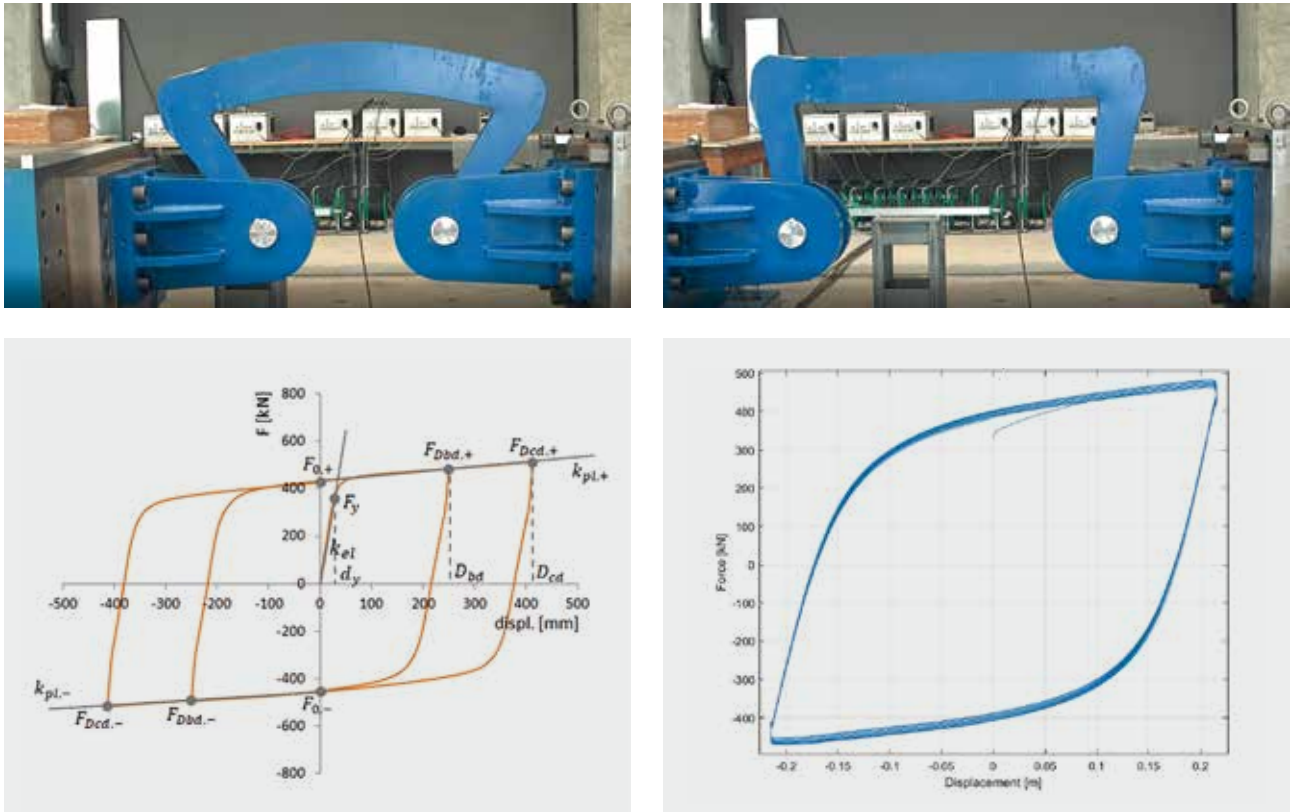


Fig. 4: Hysteretic loops calculated for displacement amplitudes d_{bd} and d_{max} were confirmed with test plots during prototype testing

Device optimization

The design of the MANTIS® hysteretic damper has been developed and optimized with non-linear FEM analysis methods. The device can even be customized when necessary to meet a projects special requirement.

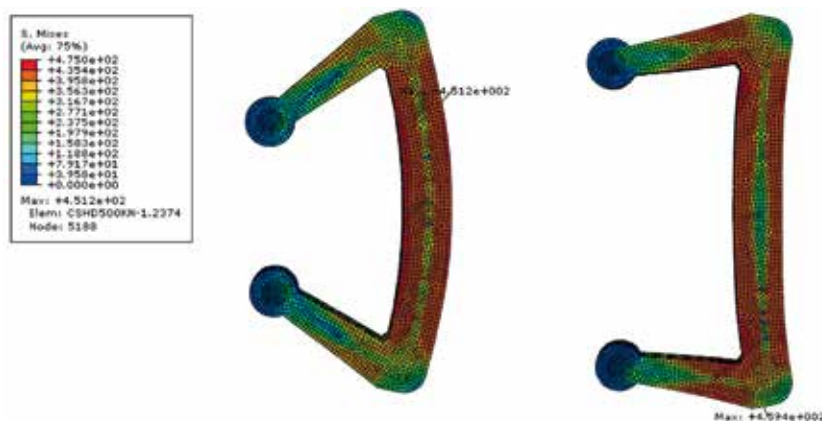


Fig. 5: FEM stress analysis for evaluation and prediction of seismic behaviour

Comparison of viscous, friction and MANTIS® damper

Characteristics	Viscous damper	Friction damper	MANTIS® damper
Influence of temperature	+++	+	++++
Accommodation of thermal structural alternating movements	++++	+	++
Function tolerances	+++	+	+++
Durability / Service lifespan	+++	+++	++++
Sensitivity to corrosion with effect on function performance	+++	+	++++
Efficiency for energy dissipation	++++	++++	++++
Easy visual inspection	++	+++	++++
Adaptive behaviour depending on seismic impact	++++	+	++
Breakaway at first seismic movement impulse	++++	+	++++
Economic cost	+	+++	++++

Ranking criteria: ++++ very good +++ acceptable ++ poor + very poor

Reference of MANTIS® damper

Basarab Overpass Viaducts in Bucarest/Romania has been fitted with LRBs combined with 24 pcs. MANTIS® devices with 500 kN each.

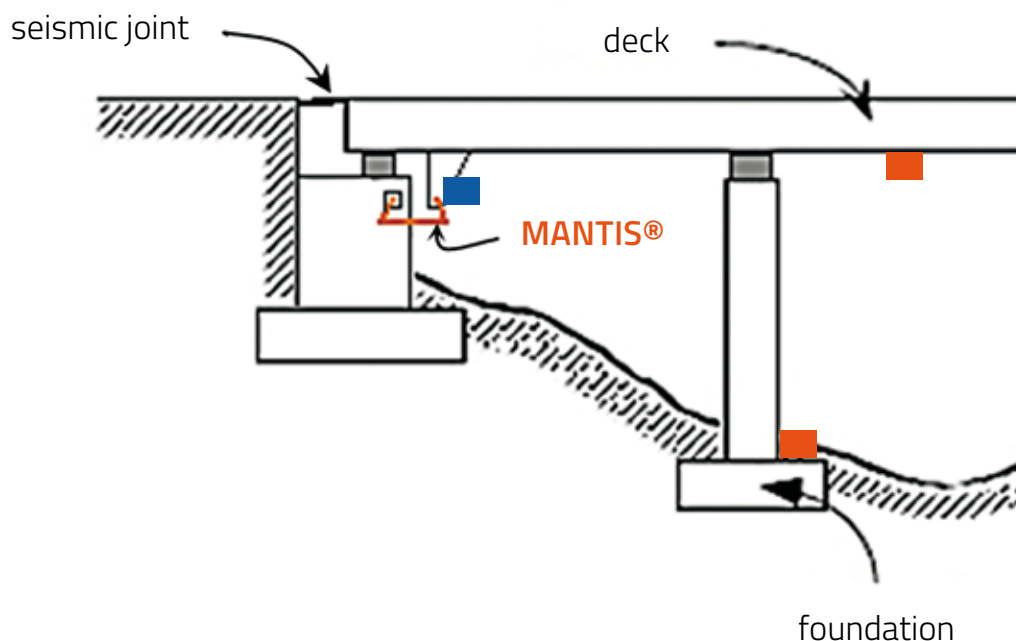


Fig. 6: Installed devices within Basarab Overpass in Bucharest

Optional MAURER MONITORING SYSTEM (MMS)

The MANTIS® system can be instrumented with the standardized basic MAURER Monitoring System (MMS-Basic). The earthquake event-triggered recorded data will be automatically analysed to check if both the structural acceleration and displacements limits have been exceeded as well as the displacement capacity of the MANTIS® system. This information is valuable to do a preliminary assessment of the structural integrity and verify its suitability to be immediately operational. The MMS-Basic1 provides a limited amount of sensors (max 16 channels) and is hence suitable for small to midsize bridges with approx. 4 spans. The MMS-Basic2 (max 32 channels) is equipped with additional sensors for bigger and more complex structures.

DATA RECORDING AND POST-PROCESSING	
Peak Ground Acceleration (PGA) & frequency content or earthquake	→ comparison with acceleration response spectrum at both MCE and DBE design levels
Peak Accelerations of deck or superstructure	→ strong events (PGA \cong MCE design level): comparison with expected acceleration levels (structural protection target) → weak events (PGA \leq DBE design level): comparison with capacity of acceleration-sensitive structural components (piers or similar)
Damper displacement	→ strong events (PGA \cong MCE design level): (a) comparison with damper displacement capacity; (b) calculation of maximum pier deformation and comparison with their flexural capacity (structural protection target) → weak events (PGA \leq DBE design level): calculation of maximum inter-storey drift and comparison with capacity of drift-sensitive non-structural components (immediate operation target) → service conditions (wind and thermal loads): cumulative displacement for fatigue analysis



Quality control

- EN ISO 9001 and EN ISO 14001
- Design, testing and quality management according to EN15129 "Anti-Seismic Devices" or other standards (AASHTO GSID-4 "Guide Specifications For Seismic Isolation Design") on request
- CE-marking (acc. to EN15129)
- Testing at independent universities
- Quality audits with client upon request

