Bridge Accessories

MAURER Swivel-Joist Expansion Joint

MAURER SÖHNE
Innovations in steel
Since 1876

MAURER Swivel-Joist Expansion Joint

The MAURER Swivel-Joist Expansion Joint is an enhancement of the Girder Grid Expansion Joint, considerably adding to the range of application of the MAURER Modular Expansion Joints. When large and complex movements are required then for geometrical and economic reasons the use of Swivel-Joist Joints are to be preferred rather than Girder Grid Joints.

Also in the case of restricted space, for instance in steel bridges and with the replacement of old rolling leaf type joints, the application of the watertight Swivel Joint is advisable.

The MAURER Swivel-Joist Expansion Joint's versatile movability makes it suitable for variable deformations along the bridge structure . The joint cannot only follow the main movement of the bridge in carriageway direction but also distinctive movements in the 2 spatial directions perpendicular to the main direction. Even rotations of the bridge about the three spatial axes are easily coped with.

The edge beams run parallel to the structural edges. In order to avoid material fatigue, the traffic loads are transmitted to the adjoining reinforced concrete structure via anchor plates which are rigidly connected to the edge beams.

Dependent on the size of movement numerous centre beams are arranged between the edge beams.
The center beams slide on obliquely arranged swivelling support bars, resting on elastic sliding bearings. Lift-off from the sliding bearing is prevented by means of a prestressed sliding spring that is arranged in the support stirrup underneath. Only in the joist-box (i.e. at the edge), the sliding spring is placed above the support bar. Stirrups provide constant prestressing that is geometrically controlled.

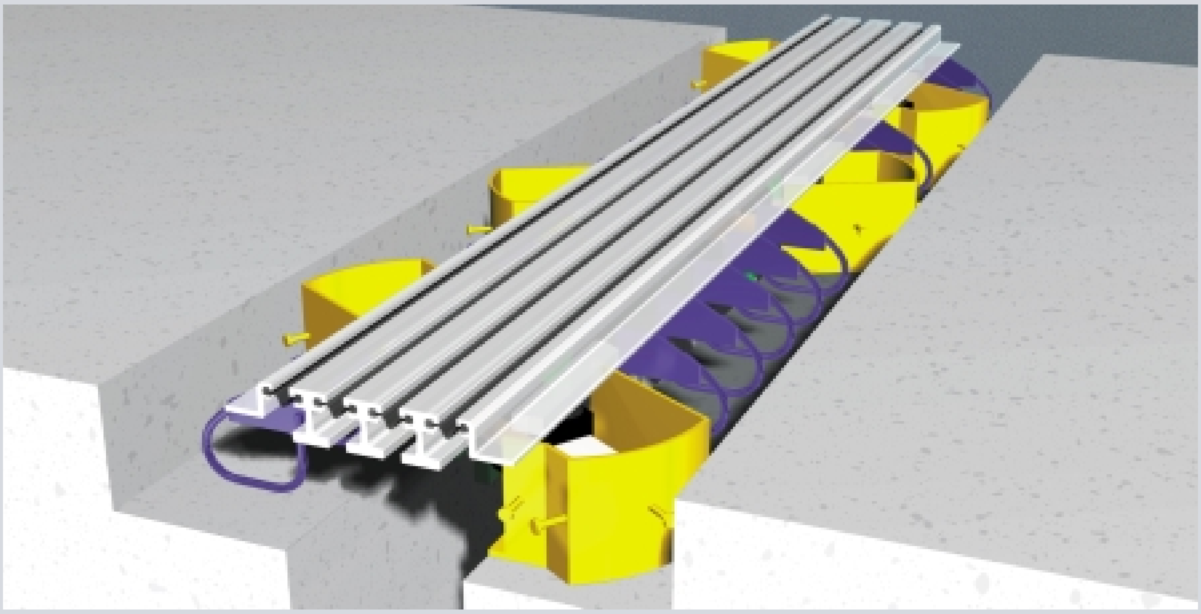
Vehicles travelling over the expansion joint transmit vertical and horizontal loads to the centre beams. The section forces resulting from the eccentric wheel loads are transmitted to the support bars (via prestressed sliding bearings) by means of the centre beams that act as continuous girders with torsionally elastic support. From there the forces are transmitted into the edges of the structure.

The bulbous-shaped EPDM strip seal is installed in a claw in the edge beam and centre beams without the need for additional clamping bars. The connection is watertight, with the sealing element set below the road surface level. This way it is protected against direct wheel or snowplough contact.
As a rule, the admissible horizontal displacement of the strip seal in carriageway direction is 80 mm. With its preformed articulated section it is possible to move the strip seal in direction of the carriageway without any appreciable strain.

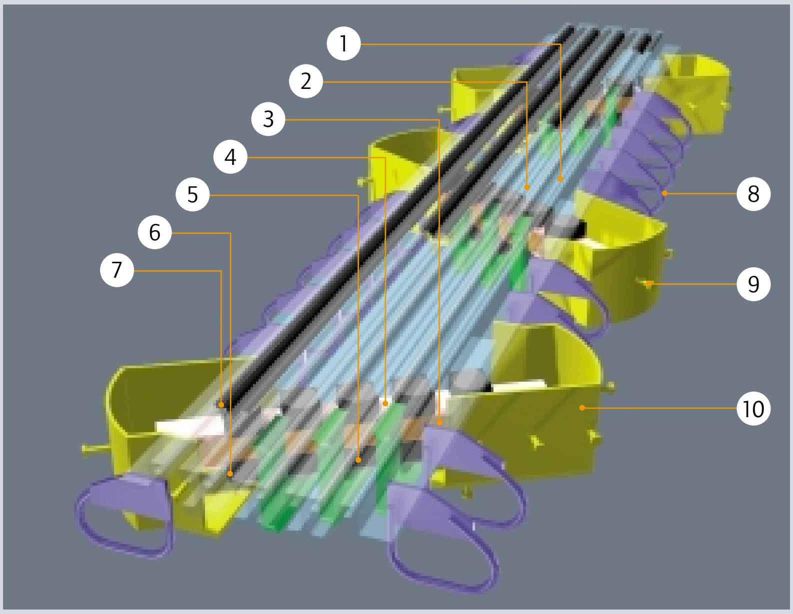
Installation of the expansion joints is carried out in total length (i.e. in 1 piece) into the prepared recess. The structural connection shall be made in accordance with the rules of reinforced concrete construction and/or steel construction. The installation is completed with the connection of the waterproofing, followed with asphalting.

Replacement of a Roller Leaf Joint by a MAURER Swivel Joist Expansion Joint

Type DS 320 displacement of the support bar on both sides



Design Principles and Main Components



Technical approval and independent periodical inspection acc. to TL/TP-FÜ

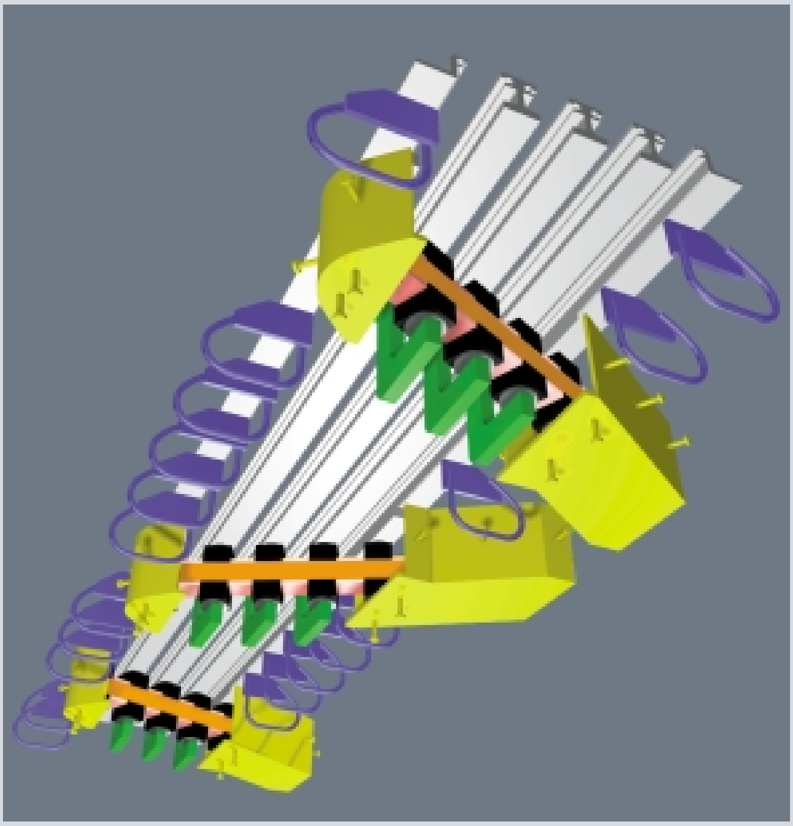
Continuous in-house and field quality control, the use of high-grade materials, a quality assurance system in complying to DIN EN ISO 9001 as well as an environmental management system according to DIN EN ISO 14001 ensure the high standard of MAURER Swivel-Joist Expansion Joints.

All design elements of MAURER Expansion Joints are engineered in high-quality materials. All synthetics employed feature excellent resistance to ageing, wear, and show a superior performance to all kinds of environmental impacts. Relaxation of the bearing elements is insignificant even after decades of service. The sealing elements are insensitive to physical stress.

National regulations are to be taken into account in the choice of the corrosion protection system. We recommend using two-coat zinc-rich paint as the primer and epoxy-based micaceous iron ore as the finishing layer.

Designation	Description
Supporting Elements	
1 edge beam	hot-rolled steel grade S 235 JR G2 with precision tolerances combining good weldability with notch toughness. Can be both shop and site butt-welded.
2 centre beam	hot-rolled steel grade S 355 J2 G3 with precision tolerances combining good weldability with notch toughness. Can be both shop and site butt-welded by a patented system.
3 support bar	steel grade S 355 J2 G3, machined for precision tolerances.
Supports	
4 sliding plate	stainless steel in bridge bearing quality material-no. 1.4401, sliding surfaces ground and polished.
5 sliding spring	natural rubber with vulcanized steel plates. Sliding surfaces of high strength PTFE sliding material.
6 sliding bearing	chloroprene-rubber reinforced with vulcanized steel plates, according to Bridge Bearing Standard DIN 4141, part 14. Sliding surfaces of high strength PTFE sliding material.
Sealing elements	
7 strip seal 80	EPDM or chloroprene-rubber with high resistance to tear propagation, resistant to salt water, oil and ageing, available in any desired length. Hot vulcanization on site possible.
Anchorage elements	
8 carriageway anchors at the edge beams	flat and round steel made of S 235 JR G2
9 anchor studs at the support boxes	St37 K
10 support box	S 235 JR G2, to accommodate the sliding bearings, sliding springs, as well as providing the space required for the support bars in motion.

Functional Principles

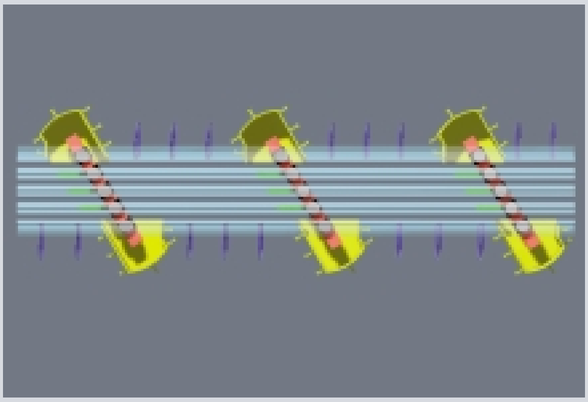


**Type DS320
displacement of a support
bar that is fixed at one side
view from below**

The centre beams of the Swivel-Joist Expansion Joint can slide on support bars with the help of sliding bearings. By means of the geometrical arrangement of the support bars the position of the centre beams is controlled such that the overall width of the joint opening is equally subdivided to the joint gaps between the centre beams and between the centre beams and edge beams respectively.

This both simple and effective control mechanism means an important advantage of the Swivel- Joist Expansion Joint. Unrestrained absorption of movements and simultaneous transmission of traffic loads is safeguarded without additional control elements and without any defined direction of movement.

In case of larger movements, in order to avoid large spans the support bars are arranged in parallel. In this case an additional restraint is required or the positioning of parallel support bars in the two neighbouring traffic directions must be arranged such that they are inclined to each other.



The resilient bearings in respect to torsion enable horizontal and also vertical displacements of the structure as well as differences in height of the joint edges in case of a longitudinal slope.

The ample space in the joist-boxes serves to accommodate the motion sequence of the swivelling support bars in motion. The total movement of a support bar can be allocated to the two edges of the joint arbitrarily. Quite frequently the movement of the support bar is absorbed at one side, for example at the abutment, whereas at the opposite edge the support bar can rotate but is fixed in its displacement.

It will also be possible that for geometrical reasons, e.g. because of prestressing cables, the one-side displaceable support bars can be arranged in an alternating way.

The total movement can be distributed to both edges of the joint as per requirement or desire, for instance in equal parts. In steel bridges the edge structure is supported on cantilevers or supporting girders parallel to the end cross girder. As a rule the cantilever plates that are fixed to the edge structure in the manufacturing site are then welded to the steel end cross girder.

In shifting the movement to the opposite abutment, the eccentricities of the traffic loads that are introduced can be reduced to a minimum.

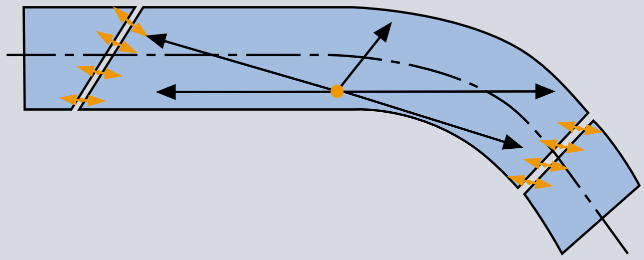
Contrary to the Girder Grid Joint, this type of Expansion Joint can accommodate the largest movements applied in bridge construction so far, which is facilitated by the fact that all centre beams are commonly supported by one support bar.

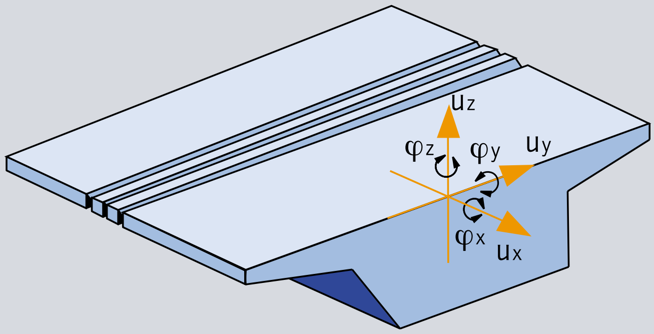
Versatility

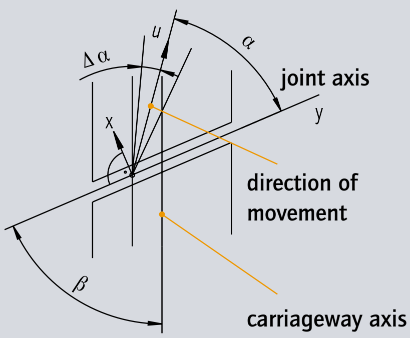
MAURER Swivel-Joist Expansion Joints can absorb all movements customary in bridge construction. The versatile mechanism of this type makes it suitable for variable skew angles along axes centred on a fixed point and also for complex hybrid movements and rotations about the spatial axes x, y and z.

The recess sizes given in the following pages will give the planner of the bridge structure some assistance for designing. The distribution of a support bar movement to each joint edge can be settled as per requirement or liking, other solutions than those shown below can be designed as well. All dimensions given are without obligation to the planner. For every project all dimensions will have to be determined case by case.

Geometrical restrictions which might be the consequence of the geometry of the boxes and support bars, can be changed by special design any time.







Due to the high standardisation expenditure resulting from Technical Test Specifications according to TL/TP-FÜ only applications of frequent use had been considered (please also refer to the appertaining documents). In Germany the admissible movement per joint gap in transverse direction to the joint-axis has been restricted to 65 mm. However, all expansion joints are designed to take movements of 80 mm. The following table shows the admissible movements for standard designs of the individual types.

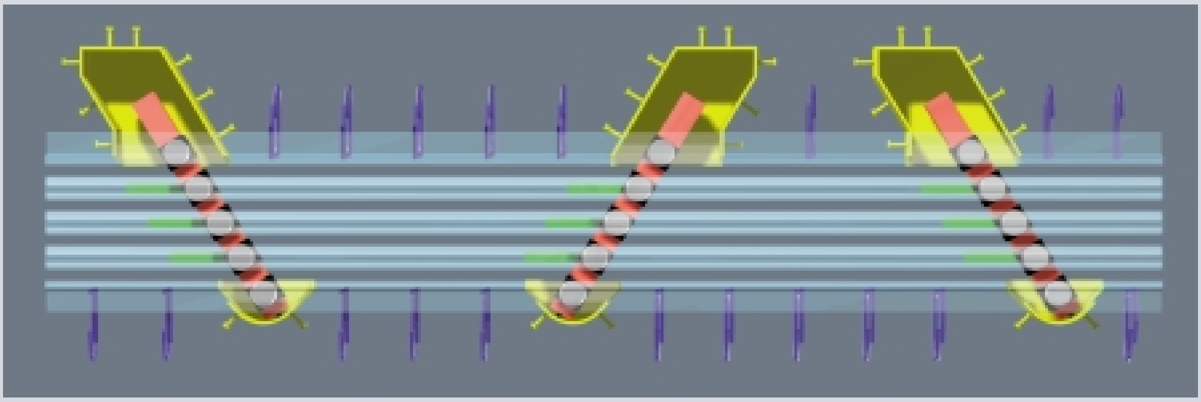
type	weight [kg/m]	type	weight [kg/m]
DS160	270	DS720	930
DS240	350	DS800	1030
DS320	440	DS880	1140
DS400	530	DS960	1260
DS480	620	DS1040	1380
DS560	720	DS1120	1500
DS640	820	DS1200	1620

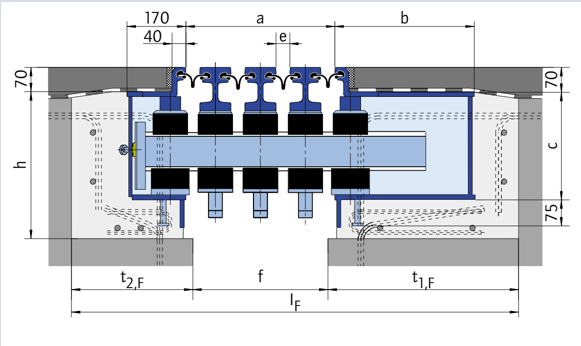
The given numbers of the weight of joints is only to calculate the size of cranes and lifting devices.

n	type	u_x [mm]	u_y *) [mm]	u_z *) [mm] mid-position	α [°]	Δα	β [°]
2	DS160	130 (160)	± 80	± 10			
3	DS240	195 (240)	± 120	± 15			
4	DS320	260 (320)	± 160	± 20			
5	DS400	325 (400)	± 200	± 25			
6	DS480	390 (480)	± 240	± 30			
7	DS560	455 (560)	± 280	± 35			
8	DS640	520 (640)	± 320	± 40	90° ± 45°	any	any
9	DS720	585 (720)	± 360	± 40			
10	DS800	650 (800)	± 400	± 40			
11	DS880	715 (880)	± 440	± 40			
12	DS960	780 (960)	± 480	± 45			
13	DS1040	845 (1040)	± 520	± 45			
14	DS1120	910 (1120)	± 560	± 45			
15	DS1200	975 (1200)	± 600	± 45			

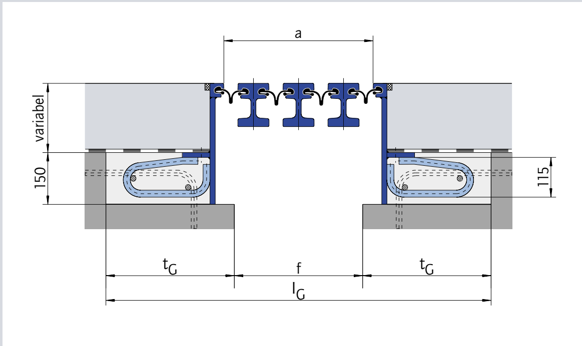
*) Values apply to standard design, bigger values are possible, too.

Movement of support bars to one side only
Recess dimensions

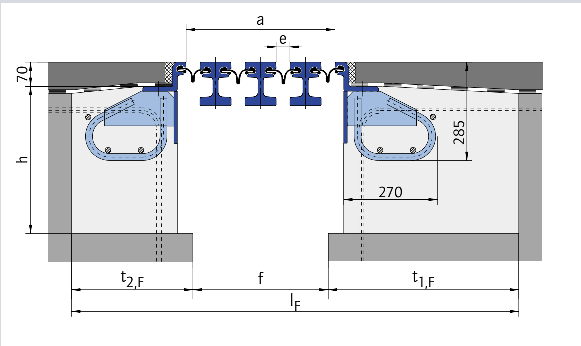




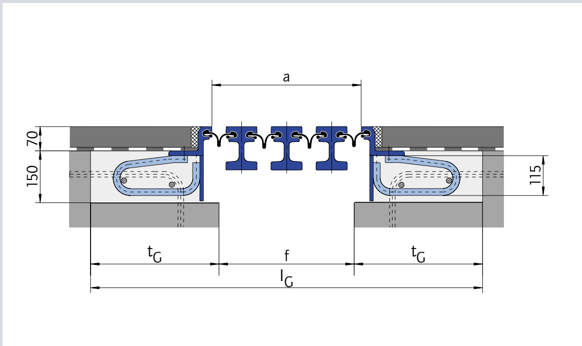
cross section through support box at carriageway



footway cross section – version 1



carriageway cross section at anchorage



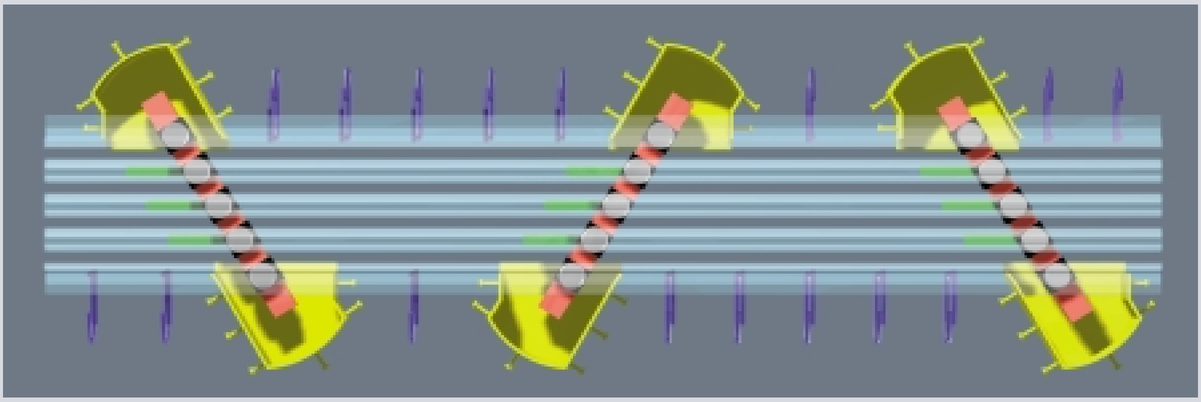
footway cross section – version 2

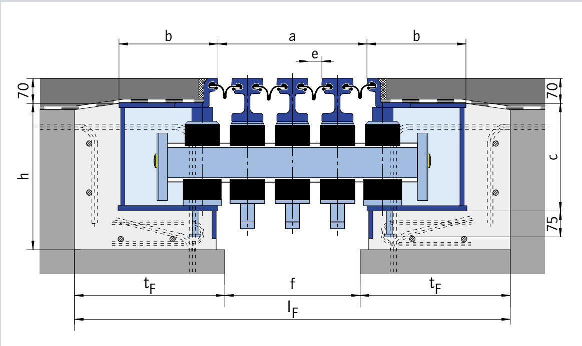
Presetting of gap dimension e = 30 mm											
MAURER exp. joint		structural dimensions			concrete recess dimensions			concrete gap dimensions			
n	type	a [mm]	b [mm]	c [mm]	h [mm]	$t_{1,F}$ [mm]	$t_{2,F}=t_G$ [mm]	f_{min} [mm]	f_{max} [mm]	l_F [mm]	l_G [mm]
2	DS160	150	260	290	420	400	350	115	130	865	815
3	DS240	270	310	300	430	450	380	225	250	1055	985
4	DS320	390	360	310	440	500	390	300	370	1190	1080
5	DS400	510	410	320	450	560	400	410	490	1370	1210
6	DS480	630	460	330	460	620	410	520	610	1550	1340
7	DS560	750	510	340	470	680	420	630	730	1730	1470
8	DS640	870	560	350	480	740	430	740	850	1910	1600
9	DS720	990	610	360	490	800	440	850	970	2090	1730
10	DS800	1110	660	370	500	860	450	960	1090	2270	1860
11	DS880	1230	710	380	510	920	460	1070	1210	2450	1990
12	DS960	1350	760	390	520	980	470	1180	1330	2630	2120
13	DS1040	1470	810	400	530	1040	480	1290	1450	2810	2250
14	DS1120	1590	860	410	540	1100	490	1400	1570	2990	2380
15	DS1200	1710	910	420	550	1160	500	1510	1690	3170	2510

For structures acc. to directives TL/TP-FÜ you must also observe the details given in the standard testing specifications

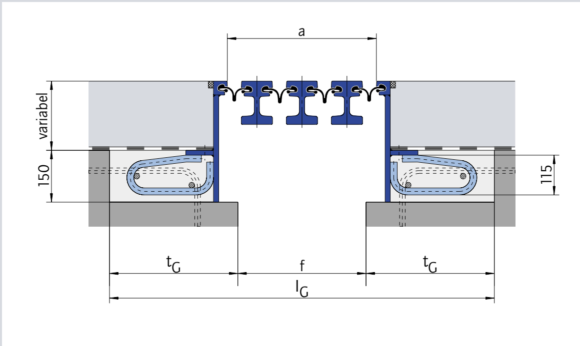
- All dimensions are rectangular to the joint axis y.
- n = number of sealing elements
- a, f and l apply to a presetting dimension e = 30 mm for every joint gap and must be adjusted by n x Δe in case of deviating presetting dimension e.
- recesses for footway joists, restraints and tube openings as a rule require prior consent between the planner of the structure and the manufacturer of the expansion joint.
- Smaller recess dimensions are possible by special design of MAURER.

Movement of support bars to both sides
Recess dimensions

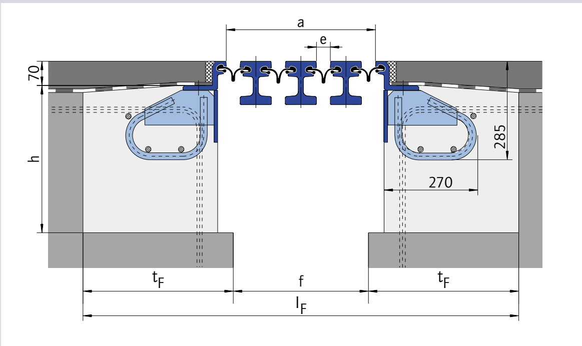




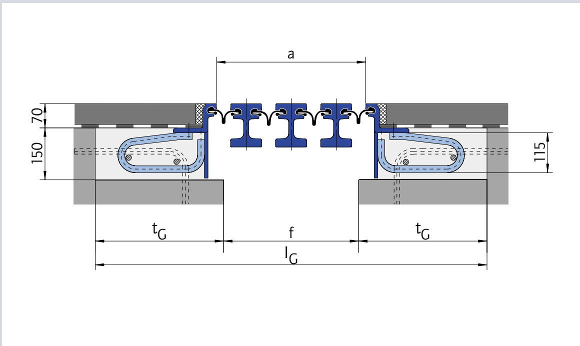
cross section through support box at carriageway



footway cross section – version 1



carriageway cross section at anchorage



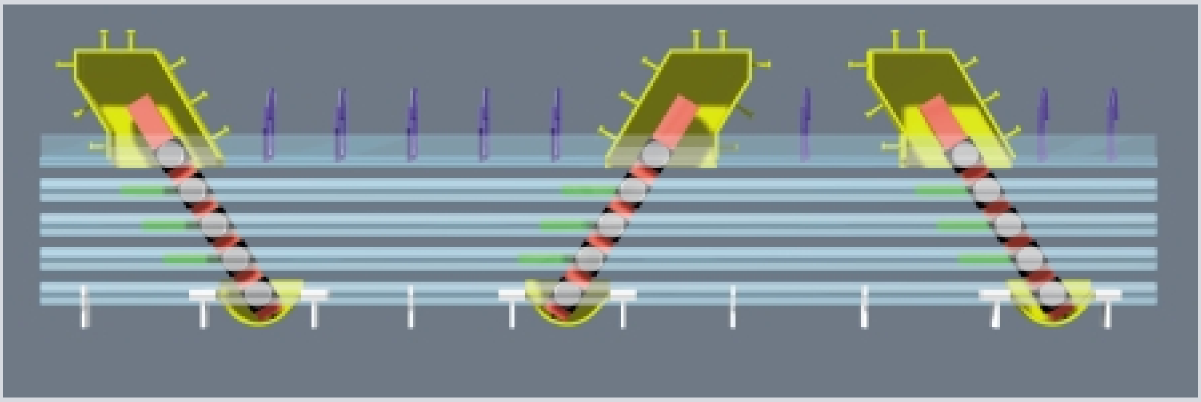
footway cross section – version 2

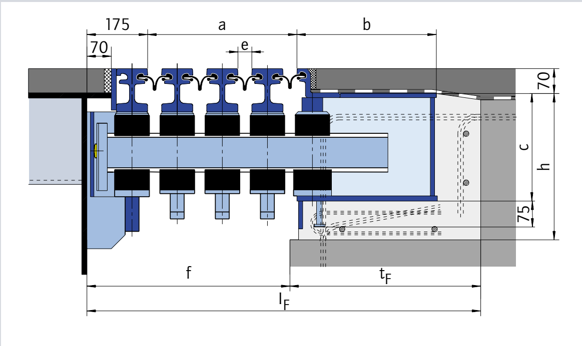
Presetting of gap dimension e = 30 mm											
MAURER exp. joint		design data			concrete-recess dimensions			concrete-gap dimensions			
n	type	a [mm]	b [mm]	c [mm]	h [mm]	t_F [mm]	t_G [mm]	f_{min} [mm]	f_{max} [mm]	l_F [mm]	l_G [mm]
2	DS160	150	215	290	420	350	350	115	130	815	815
3	DS240	270	255	300	430	395	380	225	250	1015	985
4	DS320	390	285	310	440	435	390	300	370	1170	1080
5	DS400	510	355	320	450	510	400	410	490	1430	1210
6	DS480	630	380	330	460	550	410	520	610	1620	1340
7	DS560	750	410	340	470	590	420	630	730	1810	1470
8	DS640	870	430	350	480	620	430	740	850	1980	1600
9	DS720	990	460	360	490	660	440	850	970	2170	1730
10	DS800	1110	490	370	500	690	450	960	1090	2340	1860
11	DS880	1230	515	380	510	730	460	1070	1210	2530	1990
12	DS960	1350	550	390	520	770	470	1180	1330	2720	2120
13	DS1040	1470	585	400	530	820	480	1290	1450	2930	2250
14	DS1120	1590	615	410	540	860	490	1400	1570	3120	2380
15	DS1200	1710	645	420	550	900	500	1510	1690	3310	2510

For structures acc. to directives TL/TP-FÜ you must also observe the details given in the standard testing specifications

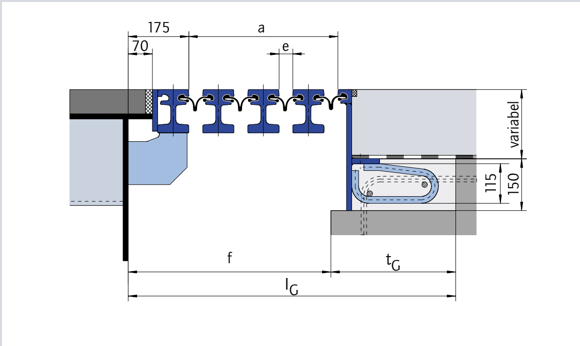
- All dimensions are rectangular to the joint axis y.
- n = number of sealing elements
- a, f and l apply to a presetting dimension e = 30 mm for every joint gap and must be adjusted by n x Δe in case of deviating presetting dimension e.
- recesses for footway joists, restraints and tube openings as a rule require prior consent between the planner of the structure and the manufacturer of the expansion joint.
- Smaller recess dimensions are possible by special design of MAURER.

Steel connection
Recess dimensions

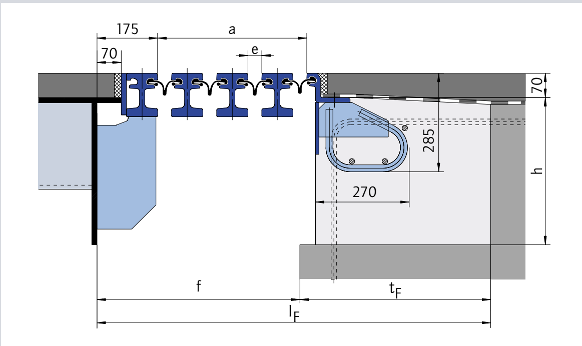




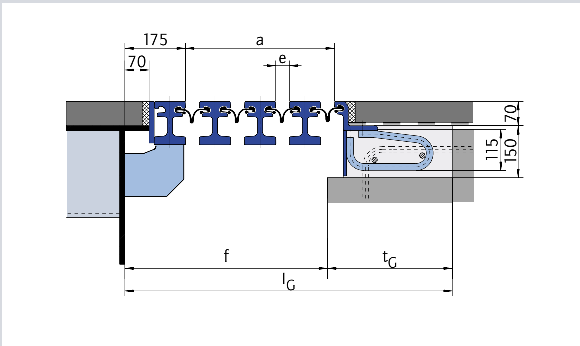
cross section through support box at carriageway



footway cross section – version 1



carriageway cross section at anchorage



footway cross section – version 2

Presetting of gap dimension e = 30 mm											
MAURER exp. joint		structural dimensions			concrete recess dimensions			concrete gap dimensions			
n	type	a [mm]	b [mm]	c [mm]	h [mm]	t_F [mm]	t_G [mm]	f_{min} [mm]	f_{max} [mm]	l_F [mm]	l_G [mm]
2	DS160	150	260	290	420	400	385	300	310	700	685
3	DS240	270	310	300	430	470	400	350	430	820	750
4	DS320	390	360	310	440	540	410	460	550	1000	870
5	DS400	510	410	320	450	610	425	570	670	1180	995
6	DS480	630	460	330	460	680	440	680	790	1360	1120
7	DS560	750	510	340	470	750	450	790	910	1540	1240
8	DS640	870	560	350	480	820	470	900	1030	1720	1370
9	DS720	990	610	360	490	890	480	1010	1150	1900	1490
10	DS800	1110	660	370	500	960	500	1120	1270	2080	1620
11	DS880	1230	710	380	510	1030	520	1230	1390	2260	1750
12	DS960	1350	760	390	520	1100	530	1340	1510	2440	1870
13	DS1040	1470	810	400	530	1170	550	1450	1630	2620	2000
14	DS1120	1590	860	410	540	1240	560	1560	1750	2800	2120
15	DS1200	1710	910	420	550	1310	570	1670	1870	2980	2240

For structures acc. to directives TL/TP-FÜ you must also observe the details given in the standard testing specifications

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- n = number of sealing elements
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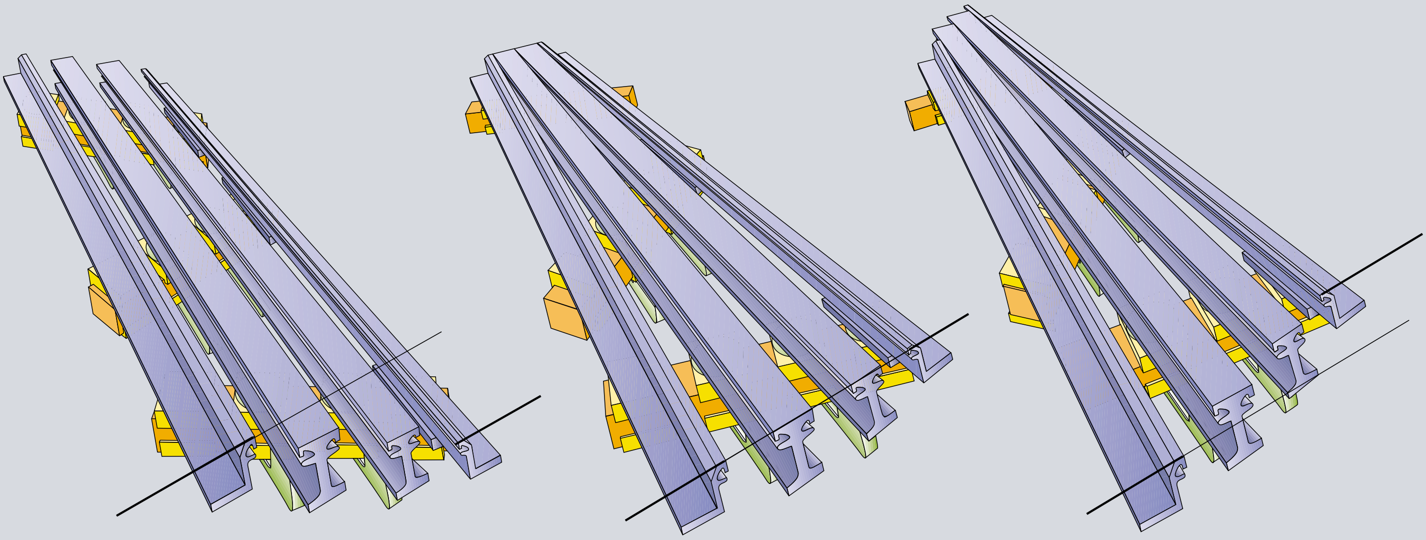
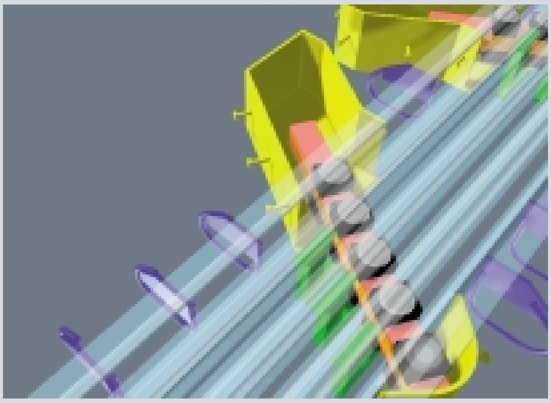
- Smaller recess dimensions are possible by special design of MAURER.

Control of Swivel-Joist Expansion Joints

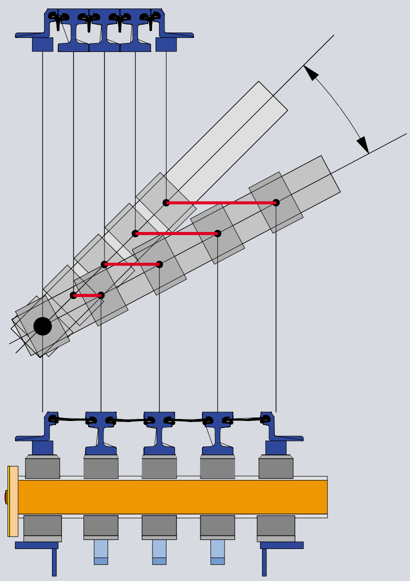




Type DS320
Control of the movement of support bars to one side

On the one hand, rigid control mechanisms guarantee an exact allocation of the total movement to the individual gaps, and this mechanism also employs a clearly defined support system. But on the other hand such a rigid control is prone to strains that are caused by unplanned and unexpected movements, such as dimensional tolerances, difference in temperature in the respective members of the joint, and deviations from the designed movement. Any support system that neither accepts dimensional tolerance nor is prestressed resiliently, gives cause to strong noise emission and high wear. For this reason, modern modular joints employ a resilient control system. Usually this is achieved by plastic springs that are either being deformed along their longitudinal axis or by means of shear deflection. The individual center beams are connected by such springs. Thus we have several chains of sequentially arranged springs. As it is the case with such a system, the total resulting stiffness is a function of the number of center beams, or modules that are connected by this way.

One exception is the swivel joint system that is being controlled by guided and shear-resilient torsion hinges. This system has all the advantages of the exact scissor control system, but, due to its shear resilience, in addition the swivel joint system can also compensate dimensional tolerances and strains. Because each center beam is controlled individually, the stiffness of the horizontal support system is independent of the number of modules, or center beams. A swivel joist system employs a control mechanism with parallel arranged springs.



If the superstructure moves, the support bars will be pushed through the swivelling guiding bearings and thus experience a swivel movement. Due to the fixed distances of the torsion elements, this swivel movement gives rise to an almost even allocation of the total movement to the individual gap openings.

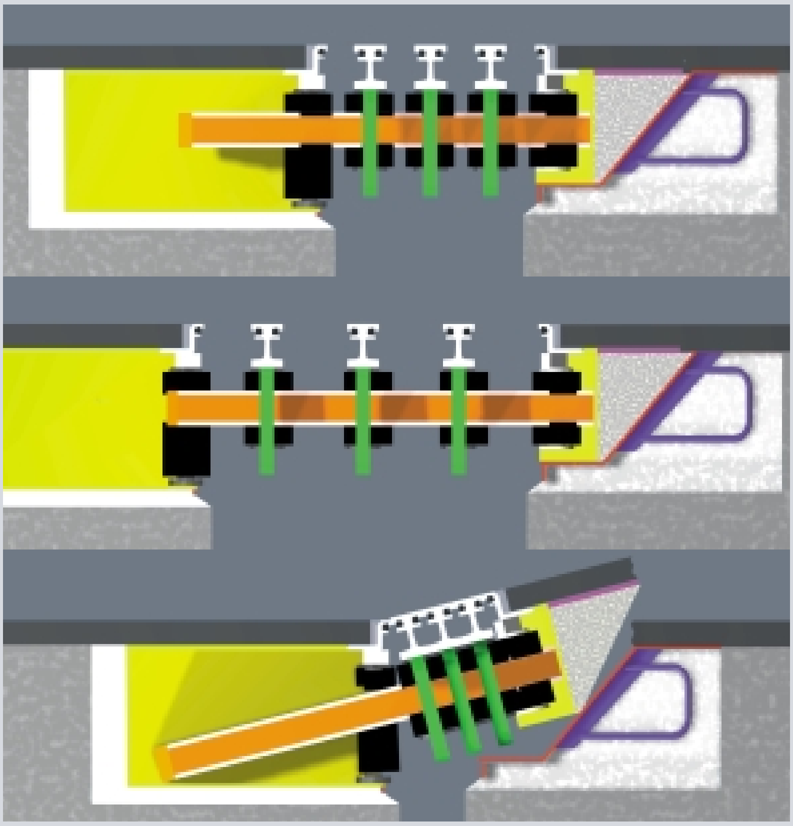
For large and irregular movements (e.g. from earthquake) there is no alternative to the MAURER Swivel-Joist Expansion Joint.

MAURER Seismic Expansion Joint

DS320 with fuse box, Maximum opened operating position (s=80 mm)

Maximum opened seismic position (e.g.: s=150 mm)

Fuse box released by earthquake, when gaps closed



Earthquakes can generate structural movements which are considerably larger, many times quicker and much more complex in their direction than those under normal operational conditions. That is why applications of that kind require particular adaptation of the expansion joint.

The conventional requirements set to the operating condition are irrelevant during seismic action. Of particular importance is, however:

- maintaining the serviceability of the structure after the earth quake at least for emergency vehicles as well as
- protection of the structure from impact damages caused by closing movements during the earthquake.

As a rule, conventional expansion joint systems can not fulfil these requirements. They are designed for movement sizes and directions under service condition. Whereas surpassing the admissible single gap widths during the quake is not dangerous in itself, this will cause the control system to be destroyed, as well as the mechanical gap width delimiters and the supporting elements. During seismic action the horizontally and/ or vertically undefinable direction of movement will eventually result in a blockage and destruction of the expansion joint. Due to high accelerations during a quake the sliding support elements are destroyed. The result will be a service breakdown of the bridge which is of vital importance for all emergency vehicles.

Employing a long and superior performance history in normal service conditions, the Swivel-Joist Expansion Joint had been further enhanced such as to also fulfil the aforementioned seismic requirements.

a.) General

There is a demand for reliable and economic solutions to cope with seismic strains. For operating condition the MAURER-SeismicExpansion Joint is dimensioned like a Swivel Joist Expansion Joint, geometrically adapted to the seismic movements. By this, the number of sealing elements as well as the wearing parts and finally the price are minimized. All movements are transmitted without constraints or damages.

b.) Direction of movement

The direction of movement is only restricted by geometrical obstacles in the support box. The unique Swivel Joist design allows for all kind of adaptations.

c.) Acceleration

Conventional modular expansion joints are controlled by springs that are arranged in series. Due to the mass inertia of the centre beams, seismic accelerations bring about inadmissible gap width deviations which finally destroy the supporting structure. In case that gap width delimiters should be provided here, the admissible opening of the Expansion joint is then however restricted to operating conditions only. The centre beams of MAURER-Seismic Expansion Joints are arranged in parallel, which means that each centre beam moves independently and hence it follows that there only minor additional gap width deviations will occur.

d.) Opening movements

The admissible gap width, which as a rule is 80 mm, can be exceeded during seismic action. The control elements, following the "theorem on intersecting lines", enable every opening condition of the expansion joint. By adapting the length of the support bars, opening conditions of whatever magnitude can be accommodated without strain. The sealing element will be adapted such as to follow the combined earthquake movements without the risk of unfolding. If for economic reasons the working range of the sealing element shall be limited, then by simple means this original limit can be restored again after the quake is over.

e.) Closing movements

When the expansion joint or the structural gap closes, there might result damages or even breakdown of the structure. For better protection of the bridge structure, MAURER SÖHNE has developped a so-called "fuse box" in addition to the new-style Seismic Expansion Joint. If the expansion joint should close in case of a quake, predetermined breaking points will be activated. The anchorage system disengages alongside a ramp according to a defined failure load and will return to its original position as soon as the quake is over. Stoppers provide temporary fixation of the position. Emergency vehicles can pass the joints. However, the anchorage will have to be reconstructed. An application of a fuse box can - as the case may be considerably reduce the number of sealing elements required.

University of Berkeley/ California Testing equipment

maximum transverse displacement

f.) Proof by testing

The behaviour of the MAURER Seismic Expansion Joint was tested at the University of Berkeley / California, actually the only institution capable to do such tests. A test specimen of type DS 560 in scale 1:1 was subject to displacements of extremely high velocity and changing directions, at the same time simulating a variety of recorded seismic patterns.

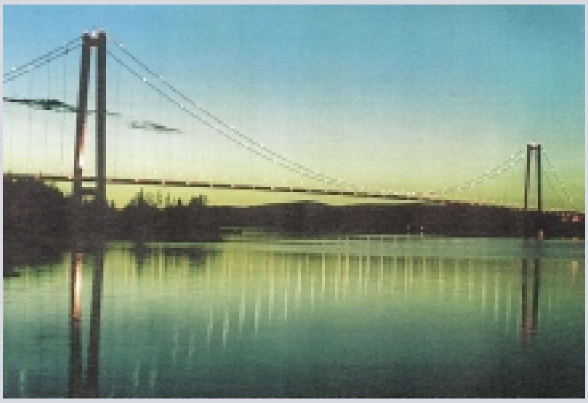
Simultaneously longitudinal and transverse displacements of 1120 mm, coupled with a vertical offset of up to 6 %, were applied at resulting velocities of up to approx. 1600 mm/s. Even after imposing 30 full seismic patterns, no damages could be detected.

Bridges with MAURER Swivel-Joist Expansion Joints

Vasco da Gama Bridge, Portugal
with fuse box for
earthquake movements
built: 1997
Cable-stayed bridge
main span: 829 m
type of joint:
DS1440 59.00 lin. metres

Storebælt East Bridge, Denmark
built: 1996
Suspension bridge
main span: 1624 m
type of joint:

DS2000	51.40 lin. metres
DS1520	25.70 lin. metres
DS1200	25.70 lin. metres
DS960	25.70 lin. metres
DS800	25.70 lin. metres



Höga Kusten Bridge, Sweden
built: 1997
suspension bridge
main span: 1210 m
type of joint:
DS1840 36.80 lin. metres

Stura di Demonte, Italy
built: 1999
Composite steel bridge
length of bridge: 2750 m
type of joint:
DS1200 24.50 lin. metres

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