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MAURER Info

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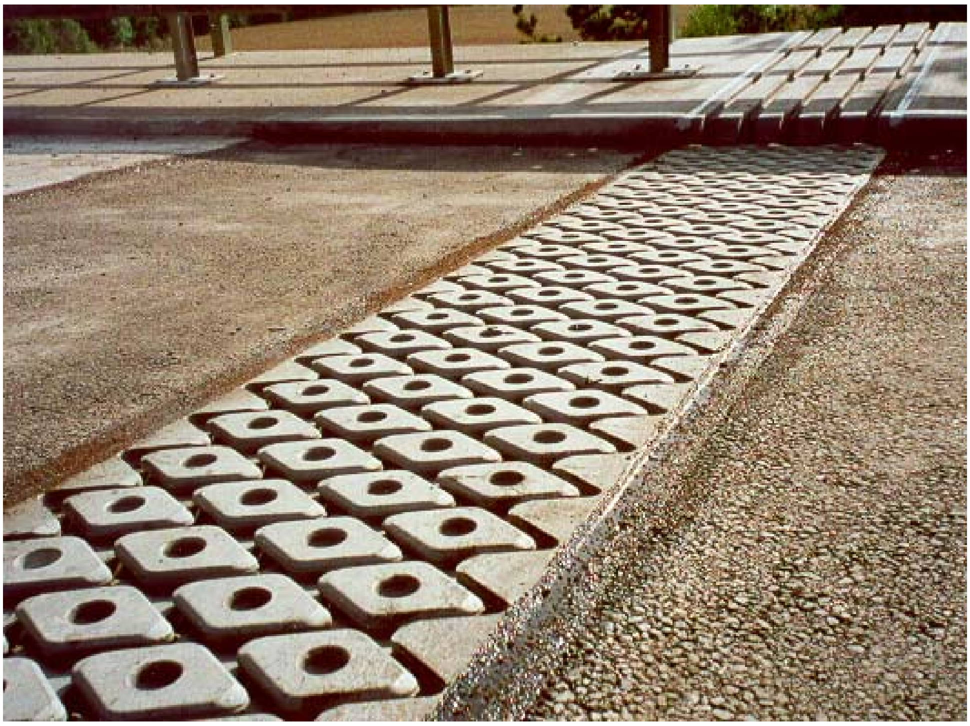
Noise Reduction of Modular Expansion Joints by means of rhombic steel plates

Objective of the investigations as described below was to minimize noise emissions of modular expansion joints that – at least in Germany – are exclusively used in bridges. We will show that in attaching overhanging rhombic steel plates to the lamellas of the joint, a functional and effective solution was developed that considerably reduces noise emissions.



... Can also be used as snowplough protection!

MAURER SÖHNE
Innovations in steel

Noise reduction of Modular Expansion Joints by means of rhombic steel plates

1. General

The embarrassment of the public due to traffic noise is an ever-increasing problem for designers of roads and bridges. In case of bridges, noise emission is not only directed to above the carriageway, but also in direction below, and is in addition also intensified due to oscillations of the bridge construction. Particularly cumbersome are noise emissions due to impact, like they usually occur at a non-smooth carriageway and at expansion joints.

MAURER has realized the importance of noise reduction of expansion joints more than 10 years ago. Since 1991, we investigate in noise reduction of expansion joints by means of test vehicles passing expansion joints of different design types.

In using the median level of the sound pressure, troubling effects of the impact like noise emissions of passing traffic are not correctly covered. So far it does not yet exist a margin on top of the median level according to which the increased troubling effect can be properly evaluated. This is why in order to evaluate the troubling effect, the difference between maximum level and minimum level was applied.

On order to evaluate the level difference between carriageway and expansion joint, an additional noise-measuring device was placed 25m in front of the expansion joint. Both noise-measuring devices were located 1.5m above and 1m beside the edge of the carriageway.

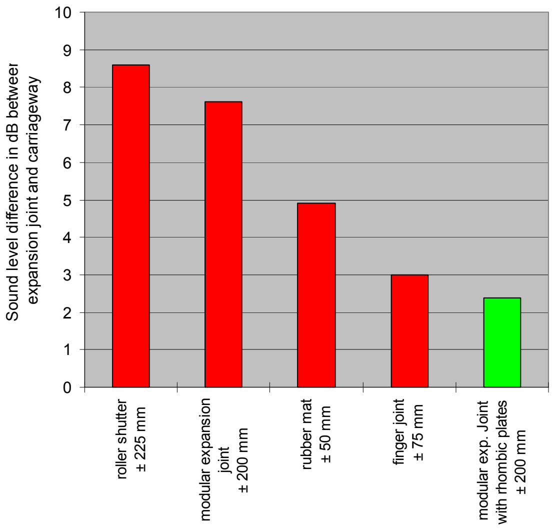


Fig. 1: Vehicle, 80 km/h

Fig.1 shows the differences of the noise levels of each 3 measurements for 4 different design types of expansion joints. In comparison to this we then display the modular expansion joints with deposited rhombic steel plates on top. Test vehicle was a medium-sized vehicle with radial tires, which employed bigger differences in noise level than in tests with a truck as test vehicle. The displayed values were taken at a velocity of 80 km/h. Measurements taken at different velocities showed that the differences in noise level were almost constant and independent of velocity.

2. Noise Reduction of Modular Expansion Joints

Objective of the tests described below was to reduce noise emissions of modular expansion joints in evaluating various modifications of and supplements to a modular joint. It was an ideal precondition that the in situ test could be carried out at the abutment of one and the same bridge.

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Likewise, in order to compare the different measurements, always the same test vehicle was used.

Basis for the selection of the different noise reducing applications was the realization that, as far as modular expansion joints are concerned, the embarrassing noise is mainly created by the wheels hitting the edges of the steel beams that are arranged rectangular to the direction of the traffic.

From the many experiments that were carried out, we would like to cite the following ones:

a) Joint gaps filled to the top of the carriageway with cut-off rubber and joint sealant

Fig. 2

The noise reducing effect stems mainly from the fact that the wheels are prevented to penetrate as deep into the gap as before. However we did not find any cut-off rubber and no joint sealant, which could sustain the strains and deformations without damage over a certain minimum time period. Minor modifications of the gap width and the strains due to the wheels lead to cracks and detachments from the joint after only a few weeks.

b) Elastic coating of the surface of the center beams in addition to the gap fillings as described in a)

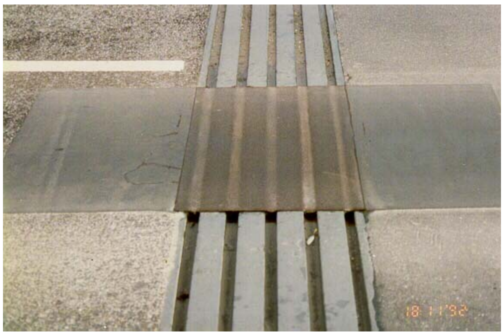

Fig. 3

In addition to the method as described in a), an elastic coating was applied over the width of the joint. Like in a), also in this case after a few weeks cracks were observed in the coating, which lead to detachments from the center beams shortly thereafter.

c) Non-overhanging, rhombic shaped plates on top of the lamella beams of the expansion joint

Fig. 4

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Objective of this arrangement was that the wheels should be prevented to hit a continuous steel edge; instead they should hit the rounded tips of the rhombus plates, which should considerably mitigate the impact. The noise reduction that was achieved in this test might be improved even further in applying thicker rhombus plates than those applied in this test.

d) Sinusoidal shaped plates on top of the center beams of the expansion joints

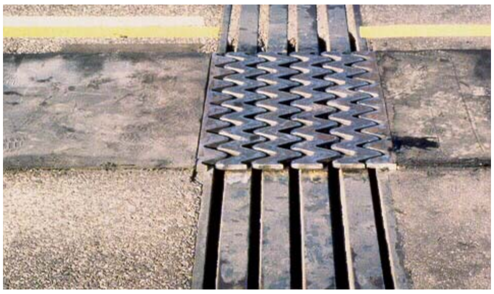

Fig. 5

Like a finger joint, the tips of the plates protrude over the gaps, with adjacent plates forming a toothing. The cantilever plate tips are not supported by the opposite edge of the beams. This design is an enhancement of the type described in c), because the sinking of the wheels into the gaps between the center beams is prevented.

e) Overhanging rhombic steel plates on top of the lamella beams of the expansion joint

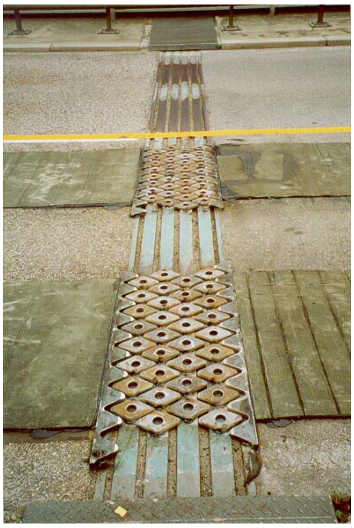

Fig. 6

The rhombic steel plates are fixed by cavity welding on the underneath arranged lamella beams. In contrast to version c), the corners of the rhombic steel plates go beyond the edges of the beams without having contact to the neighbouring beams (similar to version d)). The rhombi cover the adjacent gaps and form, as in the case of the sinusoidal shaped plates, a toothing with adjacent steel rhombi. While the noise reduction has the same value compared to version d), the fatigue resistance is considerably higher and the manufacturing is more efficient.
The test results are displayed in Fig.6. Also in this case two noise measuring devices were installed, one directly at the expansion joint and the other one in 25m distance. Both devices were located 1.5m above and 1m beside the edge of the carriageway.

Noise reduction of Modular Expansion Joints by means of rhombic steel plates

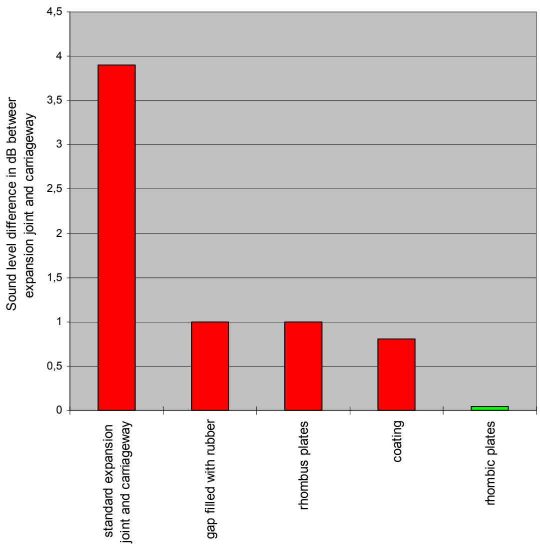

Fig. 6

Under the bridge – at the opening between bridge deck and abutment – the noise reduction of this method as compared to the „standard version" of an expansion joint turned out to be 5dB for the test truck and 9.5 dB for the test vehicle.

3. The new low-noise watertight modular expansion joint with rhombic steel plates

The comprehensive experiments and sound measurements lead to the development of the new watertight expansion joint employing "wave shaped" or "zigzag" gap openings at the surface of the carriageway.

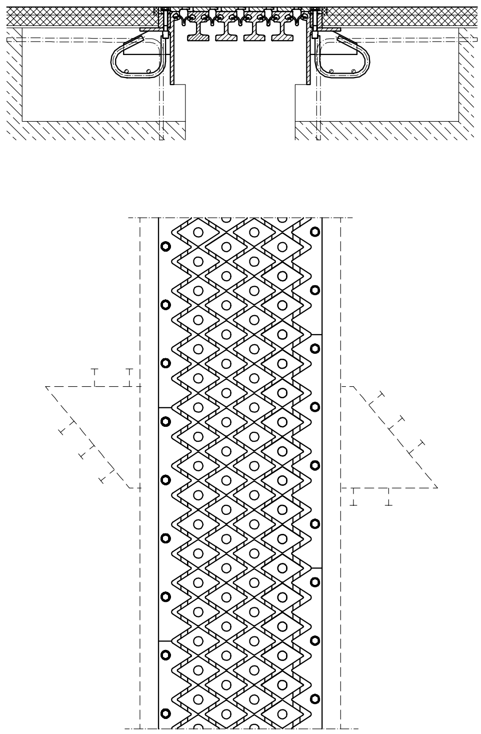

Fig. 7

Compared to conventional modular expansion joints, above and below the carriageway considerably lower sound pressure levels can be observed, to be:

Above the carriageway

- Truck at a speed of 80 km/h to be 4 dB (A) lower
- Vehicle at a speed of 120 km/h at around 6 dB (A) lower

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and

underneath the carriageway

- Truck at a speed of 80 km/h at around. 5 dB (A) lower and
- Vehicle at a speed of 120 km/h at around 9 dB (A) lower

The noise emissions of this new type of modular expansion joints are comparable to those of conventional finger joints that among experts are widely considered to emit least noise of all types of expansion joints made of steel.

Compared to conventional finger joints however, the advantages of modern watertight expansion joints still apply.

a) Vertical Deflections u_z of the 2 edges of the joint result in a slightly inclined plane that does not lead in a stepwise vertical offset.

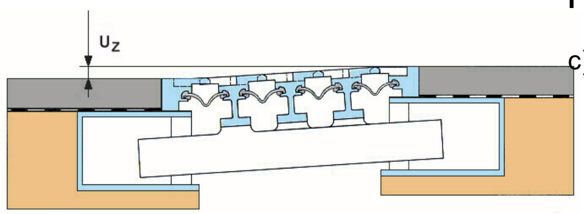

Fig. 8

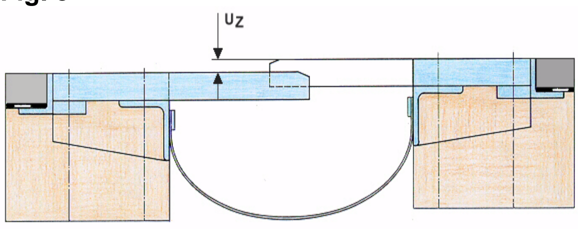

Fig. 9

b) Unplanned lateral displacements of the edges of a joint u_q can be accommodated to a considerable degree and do not, as it is the case in finger joints, after a few mm of displacement lead to a contact of the fingers, i.e. flanges of the teeth (Fig.11)

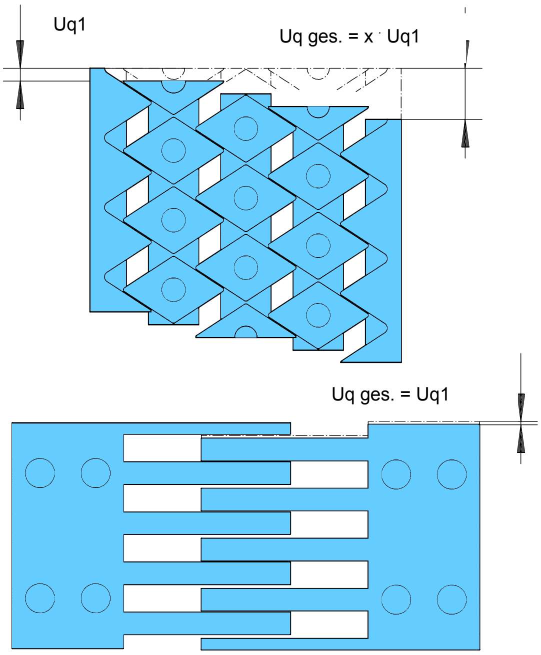

Fig. 11, Fig. 12

c) Bigger movements of the joint in main direction of the carriageway result in many small individual gaps running perpendicular to the direction of traffic (Fig.12). Conventional finger joints allow big openings, i.e. slots. These long slots in the carriageway are particularly hazardous for bicycle drivers (see Fig.13).

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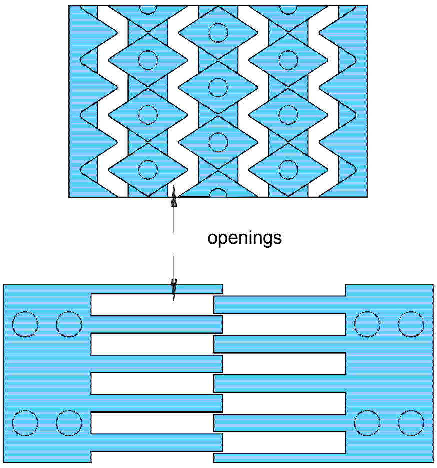

Fig. 13

d) Water and dirt will be collected by the elastomeric strip seals in the individual gaps, and are therefore prevented to protrude into the area between superstructure and abutment.

e) Center beams that are horizontally supported in a resilient manner can yield sideways to the neighboring gaps. This way, eventually squeezed particles cannot damage the expansion joint.

Further important requests were complied:

- The rhombic steel plates are not screwed to the steel beams underneath. This way we continue to stick to our philosophy that structural members that are exposed to dynamic loads, should whenever possible, not be fixed by screws or bolts to avoid danger of loosening connections.
- Sliding and control elements as well as the elastomeric strip seal can, in case of need, be replaced from above. For this purpose, the horizontally resiliently supported sinusoidal plates can be shifted to such an extent that a sufficient large gap will be created for replacement purposes.

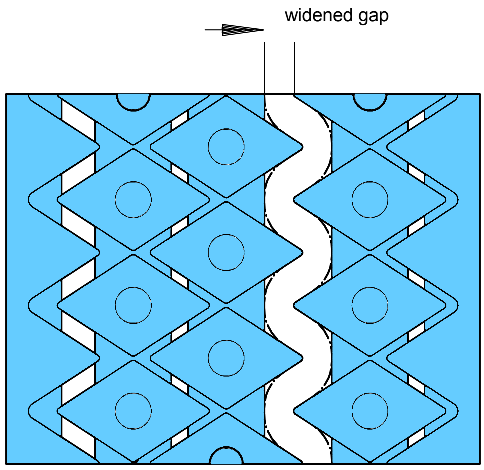

Fig. 14

- The rhombic steel plates are patented in their shape as well as in their arrangement. The length of the cantilever tip of the steel plate is limited to half of the maximum permissible gap width. This way, a relatively thin plate thickness is possible, with the plate not being supported by opposite edges of steel beams.
- These new “low noise joints” can cater to the same movement of a bridge as conventional modular joints (i.e. movement of the joint is not impeded or restricted by these sinusoidal steel plates).

  It is possible to retrofit the bridges with these steel plates, i.e. the steel plates can be welded to existing expansion joints.

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4. Winter Service

Snowploughs can pass modular expansion joints when the axis of the joint is perpendicular to the direction of traffic. However, in case the angle of the axis of the joint corresponds to the skew arrangement of the shield of the snowplough (usually this angle is between 55° and 60°), the snow shield can fall into the gap and cause damages to the joint. The solution with wave shaped gaps as described here is generally suited to prevent such accidents. Rhombic steel plates as snowplough protection should only be employed in such cases where the above-mentioned angles correspond. We would like to add that skew arrangement of gaps lead to a considerable reduction of noise.

Proposal for specification:

Noise reducing design at the surface of water-tight modular expansion joints by means of wave shaped gaps (System MAURER or similar)

The rhombic steel plates must not be screwed to the supporting lamellas (center beams). Cantilever parts of the plate must not touch parts below (i.e. no 2nd support).

The thickness of the cantilevering plates shall be designed according to structural and constructive requirements, shall however not be less than 15 mm. Strip seals as well as sliding elements and control elements must be able to be replaced from above.

The noise reducing design must be carried out over the total width of the carriageway. The asphalt must connect in level to the upper edge of the sinusoidal plates.

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REFERENCES

Reference projects	Owner	MAURER Order no.	Type	Comment
Ursteinbrücke Niederalm	Amt der Salzburger Landesregierung	57 0224	DF100	under traffic
Salzachbrücke Paß Lueg	Amt der Salzburger Landesregierung	57 0232	DF60 / 24-I	under traffic
K5, Innbrücke Kufstein Inntal-Autobahn	Amt der Tiroler Landesregierung	57 0246	DF180	under traffic
A10, Raschl- und Almbrücke	Amt der Salzburger Landesregierung	57 0257	A-D80 W / 24	under traffic
Amraser Brücke, A12 – B2	Amt der Tiroler Landesregierung	57 9011	DF60 B / 16-I	under traffic
BW 17 / 3 + 17 / 4, Autobahnring München. WL Salzburg - RFB N	ABD München	59 0112	D80 Ü	under traffic
BW 18, B31 zwischen Freiburg und Kirchzarten	SBA Freiburg	59 0141	D80 Ü	under traffic
BW 3, Fischenzstraße Konstanz	SBA Konstanz	59 0409	D80 Ü	under traffic
BW 322-2, Talbrücke Trockau, A9	ABA Nürnberg	50 0613	D560	installed
Etschbrücken in Marling Autostrada ME-BO	Autonome Provinz Bozen	56 0777	DF80 DSF240	under traffic
Brücke Villnöss	Autonome Provinz Bozen	56 0808	D80 F / D240 F	under traffic
BW 7, Brücke über die Wehra	SBA Bad Säckingen	50 0839	D240	under traffic
BW 30 und BW 31 der A10	ABA Brandenburg	54 0863	D240	in production
BW 5, Talbrücke Zschonergrund	ABA Sachsen	50 0878	D240	under traffic
BW 40a, BW 41, Berliner Ring bei Ludwigsfelde	DEGES, Land Brandenburg	54 0880	D80 B-Ü D240	under traffic
Moselbrücke Wehlen	SVA Trier	50 0960	DS240	under traffic
Brücke über den Mühlengraben	TBA Cottbus	54 0961	D80 B-Ü	under traffic
BW 235, Innbrücke Suben	ABD Regensburg	50 0965	D400	under traffic
Barmbeker-Ring-Brücke, Hamburg	Stadt Hamburg, TBA	55 7590	D240	under traffic
Moselbrücke Mehring	SVA Trier	56 1334	DS400 / D80 Ü	under traffic
BW 15, Talbrücke Weißeritz	ABA Sachsen (Dresden)	56 1344	D400 Übe 1	planning stage
Autobahndreieck Neukölln, 5 Brücken	Senat Berlin	56 1345	D160 / D240 D320	in production
UF der OEG / L 637 Neubau 1. BA (Ost)	ABA Karlsruhe	56 1455	D80 Ü GO	under traffic
Donnergraben- und Eckgrabenbrücke	Amt der Salzburger Landesregierung	57 9020	D300 GO / 14 D140 GO / 14 D200 GO / 14	in production
BW 3, Talbrücke Münchingen	SBA Besigheim	50 1504	D320 GB	in production
A23 Udine – Tarvisio, 5 Bauwerke	Autostrada Udine-Tarvisio S.p.A.	56 1505	DS560 GO und fuse box	under traffic
Brücke ü.d. DB bei Ringsheim	SBA Offenburg	56 1539	D160 GO	under traffic
BW 33, Müglitztalbrücke	Freistaat Sachsen	54 1713	D400 B-GO	planning stage
Bulacher Hochbrücke, Karlsruhe	TBA Karlsruhe	56 1531	D160 GO D80 Ü GO	under traffic
Schanzlbrücke Passau	SBA Passau	56 1534	D160 GO	under traffic
BW K10, OU Wallau-Biedenkopf,	ASV Marburg	50 0871	D240 GO	under traffic

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REFERENCES *(continued)*

Reference projects	Owner	MAURER Order no.	Type	Comment
A 12, Westabfahrt Innsbruck	Amt der Tiroler Landesregierung	57 0265	D120 GO / 9	under traffic
K 56 / 2, Pfettrachbrücke	ABD Südbayern / DS Regensburg	50 1592	D240 GO	under traffic
Haller Innbrücke, B 171 A	Amt der Tiroler Landesregierung	57 0267	D120 GO / 9	in production
BW306a, Mainbrücke Dettelbach	ABD Nordbayern / DS Nürnberg	50 1615	D560 GB D320 GB	1. BA: installed 2. BA: planning stage
BW 15-1, Wernbrücke Geldersheim	SBA Schweinfurt	50 1619	D240 GO	in production
A 71, Talbrücke b. Maibach, BW 6-2	SBA Schweinfurt	50 1668	D480 GO	planning stage
B 260, Umgehung Fachbach – Bad Ems, Lahnbrücke 1	SPA Vallendar	50 1450	D480 GO D320 GO	installed
Uferbrücke Neckarelz	SBA Heidelberg	50 1720	D320 GO	installed
Moselbrücke Traben-Trarbach	SVA Trier	50 1728	D240 GO	planning stage
Nibelungenbrücke Regensburg, BW 2, 3 und 4	TBA Regensburg	50 1729	D80 Ü / 180 GO	in production
Talbrücke Pilsach	ABD Nordbayern / DS Nürnberg	50 1831	DS480 GO	planning stage
Schanzlbrücke „Süd“	SBA Passau	50 1816	D240 GO	planning stage
Naabbrücke Schwarzenfeld	SBA Sulzbach-Rosenberg	56 1854	D160 GO	planning stage