Head Office
P.O. Box 440145, D-80750 München
Frankfurter Ring 193, D-80807 München
phone (089) 3 23 94-0
fax (089) 3 23 94-329

Main Branch Office
P.O. Box 63 40, D-44520 Lünen
Zum Holzplatz 2, D-44536 Lünen
phone (0231) 4 34 01-0
fax (0231) 4 34 01-11

Subsidiary Plant
P.O. Box 55, D-02992 Bernsdorf
Kamenzer Str. 4 - 6, D-02994 Bernsdorf
phone (035723) 237-0
fax (035723) 237-20

MAURER Info

Nr. 30 (gb)
VBA
11/99

MAURER DB Joints Manufacturing and Installation Instructions

1. GENERAL

The German Federal Railways use three different types of expansion joints to bridge movement joints on bridge structures:

- Jointing plates, primarily for longitudinal joints between two superstructure elements, where movement is minor.
- Watertight expansion joints for medium size movements.
- Open joints for large-scale movements, generally as cross (transverse) expansion joints on large valley and river bridges.

As a leading manufacturer in watertight expansion joints for road bridge construction, MAURER SÖHNE has developed a similar system for transverse and longitudinal expansion joints in railway bridges.

2. Description of the System

MAURER type DB expansion joints essentially consist of 5 elements (Fig.1):

1. A mat section that absorbs the movement of the structure.
2. A clamping section which pretensions the mat section and thus provides a watertight fixing.
3. A substructure anchored to the adjacent structures, in the form of angle sections that are concreted in or welded.
4. A screw fixing to apply pretensioning.
5. An elastomer sealing to cover the joint to the structure seal.

2.1 Mat section

Three section (profile) sizes are used for the different areas of movement. The cross sectional dimensions are given in the table below.

TYPE	Movement in x direction (perpendicular to joint axis)	Movement in y direction (parallel joint axis)	Vertical movement
DB 40	+- 20 mm	+- 40 mm	+- 20 mm
DB 80	+- 40 mm	+- 60 mm	+- 40 mm
DB 130	+- 65 mm	+- 100 mm	+- 65 mm

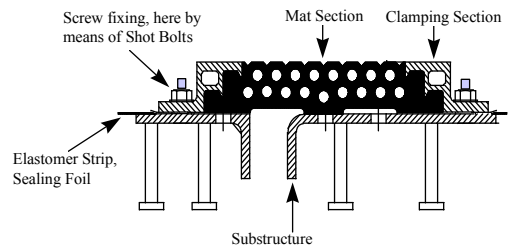

Fig. 1 Design Principle of a Maurer DB Joint

The material used is SBR with a Shore hardness value of A 58 +- 5.

Horizontal and vertical changes in the DB mat section are absorbed by corresponding vulcanized mitre joints.

Furthermore, the following criteria hold for the definition of the material characteristics of SBR:

- elongation of the mat should not exceed a certain percentage of the length of the mat

- vertical and lateral movements should be feasible without any inhibitions (no use of force). To achieve this, the stiffness of both the cross section and the material should be relatively low (which is not the case if the cross section would be reinforced)
- A further requirement is the sufficient stability of the shape. Which will be facilitated by a predeformation of the mat section in z-direction
- the vertical bending stiffness must act against the load of the ballast
- very limited tolerances in manufacturing, to guarantee optimal clamping mechanism and thus watertightness

2.2 Clamping Section

The aluminium section ensures maximum dimensional accuracy. In contrast to steel sections, which have a tenfold dimensional tolerance, these enable controlled pretensioning. The material used, Al Mg Si 1, is resistant to all media with which it might come into contact in use. The strength class F31 ensures safe absorption of stresses generated by pretensioning and expansion of the mat section.

2.3 Substructure

The expansion sections are fitted under tension on the substructure. This substructure is anchored rigidly to the adjacent structure. In the case of reinforced concrete structures, this is done with head bolts (anchor studs), which are welded at the L-shaped angles and exert their effect in conjunction with the adjacent reinforcement bars. In the case of steel superstructures, the substructure is welded directly. For the DB 80 and DB 130 design types, the expansion section is supported in the centre by the substructure.

2.4 Screw Fixing

In order to ensure that the expansion section can be fitted and dismantled easily, the clamping sections are fixed with screws. To provide protection against corrosion and ensure pretensioning, galvanised M16 screws to quality 8.8 are used. The controlled pretensioning (F = 37kN per screw, distance of screws 175 mm) generates the contact pressure on the clamping plate of 6 N/sq.mm as required to provide the sealing function.

An alternative method that was developed only recently is to use shot bolts that are welded onto the L-shaped angles on site. Same pretensioning as with screws is possible. This allows the manufacturer to assemble to DB joint on site. Which employs considerable advantages, because this design principle allows that the substructure can be embedded in a precast segment, and on site there is no recess required, considerably facilitating the traffic on the bridge deck during construction.

2.5 Elastomer Strip (Sealing Foil)

The actual joint seal is made in the contact area between the mat section and the elastomer strip. The latter is bonded between the double layer of the structure seal and covers the substructure up to the leading edge of the clamped part of the expansion section.

3. Installation of the DB joints, conventional style (Germany)

The conventional style refers to the fact that in Germany the L-shaped angles will not be installed separately, as it is the case in the Highspeed Railway project in Korea.
The German way of installing the joints is such that the total DB-joint is being manufactured in the workshop (i.e., both superstructure and substructure of the joint). This total joint is then lifted into an existing blockout, connected to the existing reinforcement, and the blockout will then be concreted.

The following figure illustrates this conventional method in showing a DB160 joint, that is 2 DB80 joints connected in series, that were manufactured at the Maurer workshop and lifted into the recess.

MAURER DB Joints Manufacturing and Installation Instruction

3.1 Delivery

a) Conventional Method

The joints will be delivered in complete length and completely manufactured (*see Fig 2*).

The locations where to lift the joint will be marked. The weight of each joint will be displayed on each joint. The joints have to be safely stored on site, and they have to be stored on an appropriate foundation like wooden bars.

For the dimensioning of the crane, the weight per linear meter of the joints is as follows:

DB40:	72 kg / m
DB80:	91 kg / m
DB130:	108 kg / m

Fig.2: Conventional Installation Method, showing a DB160 joint readily manufactured in the workshop, lifted into the recess and concreted. Humboldthafen Berlin, Germany

b) Alternative Method

The alternative method requires no recess. Here, the substructure is already firmly embedded into the concrete, and only the L-shaped angles will be seen that accomodate the shot bolts and the superstructure of the joint (i.e., mats sealing foil and clamping section).

In September 1999, this alternative method of fixing the superstructure to the substructure by means of shot bolts was successfully fatigue tested at the Technical University of Munich.

The following figure shows the situation at the job site:

Fig.3: Korean High Speed Railway: Substructure is embedded into the precast segments. Shot bolts are welded on site that will later accomodate the superstructure of the joints

3.2 Blockouts and connection to the bridge deck (conventional method)

The size of the blockout in the bridge deck has to be determined in the planning phase according to the standard drawings. The width of the structural gap has to be considered in relation to the selected presetting. The block out dimensions have to be rechecked prior to the installation, and have to be corrected if necessary.

The connection to the bridge deck has to be carried out according to the regulations of concrete construction, respectively steel construction. Prior to the installation of the railway joint, care has to be taken that sufficient connecting reinforcement will be placed. We would like to emphasise that too much reinforcement is detrimental to the quality of the concreting, because some voids might remain underneath the substructure, obstructing the anchorage of the substructure into the bridge deck.

3.3 Controlling the presetting

The design engineer determines the presetting dimensions according to the temperature on site. In case of no special indications, the joints will be preset in the workshop to an expected temperature of the bridge deck of +10°C. The respective presetting value is then defined in the approved shop drawings.

The values for the presettings that are a function of the temperature can be taken from the tables of the work shop drawings.

Prior to installation, the medium temperature of the bridge deck has to be taken, and with this temperature, the respective presetting has to be taken from the table:

Temperature of the Bridge Deck °C	Required Presetting (mm)
+5	
+10	
+15	
+20	

Depending on the required presetting, the existing presetting has to be adjusted. A higher temperature requires a closure of the joint, and a lower temperature an opening. To achieve the modified presetting, the screws of the movable mounting devices have to be losened, the new presetting dimension has to be set, and after setting the screws have again to be firmly fixed.

The following figure depicts the presetting device that is used when presetting is carried out in the workshop:

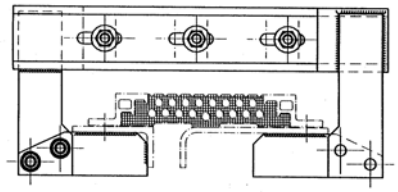

Fig.4: Device for presetting the mats in the workshop

It has to be emphasised that presetting is simpler in the workshop, that is when the conventional installation method is applied. On site, presetting is possible, albeit slightly more cumbersome.

3.4 Steel works to be carried out for the expansion joints at installation

Each joint has to be lifted into the blockout by a suitable auto-crane, and then levelled according to the slope in longitudinal and lateral direction (See Fig.2).

After this levelling is finished, vertical stiffeners that will be used as auxiliary support will be shot-welded to the L-shaped angles. The anchor studs will then be welded to the existing reinforcement. It has to be observed that preliminarily only at one side of the joint the anchor studs shall be welded with the reinforcement. At the other side eventually additional reinforcement has to be placed for the horizontal anchorage of the anchor studs, to be welded with the existing reinforcement.

In welding of the remaining anchor studs with the existing reinforcement of the bridge deck, the expansion joint will be safely fixed in its final position.

After the welding to the existing reinforcement, the joint has to accomodate the occurring movements of the bridge deck, without inhibiting the curing of the concrete.

3.5 Formworking and concreting

Formworking and concreting will be carried out by the contractor. Care has to be taken that no concrete will protrude into the structural gap. Prior to concreting, the blockout has to be thoroughly cleaned, and the correct position of the expansion joint has to be verified.

The quality of the concrete in the block out has to be at least of the grade of the one of the bridge deck, or at least of B35 or higher.

In using the alternative installation method, the total substructure can be embedded into the precast segment when these are produced. In that case, no concreting will be required at the job site, and no auxiliary bridges are required to pass a recess (because no recess required in that case).

3.6 Sealing of the bridge deck

To prevent the intrusion of water between the edges of the expansion joint and the concrete, the sealing layer of the expansion joint has to be connected according to the existing local stipulations and standards.

The following figure depicts the application of the sealing foil in case of alternative installation. The sealing foil will have to be punched, and then placed properly over the shot bolts. Care has to be taken that the outer edge of the sealing foil is properly connected to the waterproofing of the bridge deck, to avoid water to ptrotrude underneath.

4 Installation of the DB joints, Alternative Method

The installation sequence that is shown below was developed to correspond to the special requirements of the Korean High Speed Railway Project.

Main focus was to develop a solution that enables an installation for precast segments, which had a number of conditions:

- Joint substructure to be embedded into the precast segments at the time of casting these segments
- Guaranteeing a transversal construction tolerance of at least 10mm
- Gap width at time of installation 30mm
- Spacing of the anchor bolts such that they will not interfere with the longitudinal reinforcement of the top slab

The solution presented below caters to these preconditions. We would like to point out that below we describe only the rough sequence of installation. Details of the installation will be provided in due time, prior to the installation of DB mats at a given project.

The installation sequence will be as follows:

1. Embedding the L-Profiles into the precasting segments, according to customer requirements.
   This way these L-profiles become part of the precast segment. By the time of precasting, the spacing will be arranged such that it will not interfere with the longitudinal reinforcement of the top slab, while guaranteeing at the same time that the anchor forces are safely transmitted into the precast segment.

2. Installing the precast segments
   A process where Maurer is not involved. Care has to be taken that the tolerances that are required by the customer will not be exceeded.

3. Fixing threaded bolts (shot bolts) onto the L-profiles
   Threaded bolts of size M16 will be "shot" onto the L-profiles. These threaded bolts will later on accomodate the bolts that fix the aluminium clamping section to the L-section. As a kind of help, a template will be made that defines the distance and the axis of the threaded bolts that will be "shot" onto the L-profile. By this, we can safeguard the tolerances that we need to fix the aluminium clamping section toward the L-profile.

4. Fixing the aluminium clamping section and installing the mat section
   With bolts duly fixed according to our tolerance requirements, the final assembly of the railway joint on site will be carried out.

Fig.5: Korean High Speed Railway: Applying the sealing foil and connecting the sealing foil with the adjacent sealing (Alternative installation method)

5 Working procedure for vulcanisation of the DB mats type DB40, DB80, and DB130

Vulcanisation can be carried out both in the workshop and on the job site. Not only butt joints can be vulcanised, but also T-pieces, or connections to especially developed longitudinal railway joints.

The following working procedure illustrates the vulcanisation of a butt joint, as shown in Figures 6 and 7. The sequence of vulcanising is as follows:

1. Cut both ends of the DB mats such that the end surface is absolutely smooth.

2. Fill the holes of the mats with plugs of diamter 15mm and 8mm, about 30mm long, such that the surface remains smooth (no protruding of plugs)

3. Roughen the end surfaces and the first 40mm of the DB mats with a wire brush.

Clean the roughened surfaces thoroughly with a cleansing liquid („Dytex“ in Germany)

Fig 6: Humbolthafen Berlin Germany: Vulcanisation tool for vulcanising of DB80 mat

MAURER DB Joints Manufacturing and Installation Instruction

4. Paint these surfaces with crude rubber (fluid, primer) and let the surfaces dry (..partial drying)

5. Cut the crude rubber (solid) for the butt joint, around the mat and between the joint.
   Width is 50mm. Doing this, the strength of the mat section has to be observed. In case of differences, the crude rubber (solid) has to be inserted twice.
   The solid rubber that will be placed between the 2 ends, has to be rightsized according to the profile of the mat section, such that the vulcanisation profiles of the heating form can be inserted.

6. Clamping devices shall be positioned on the mat sections. However, the threaded rod that are part of the clamping devide shall not yet be mounted.

- Insert the mat sections and the strip of crude rubber into the vulcanisation form
- Lay out the vulcanisation forms straight, and also the 2 ends of the DB mats straight, that is in line with the vulcanisation form.
- Insert the crude rubber into the lower part of the vulcanisation form
- Stick one or two strips of crude rubber to the front side of the DB mar section (end)
- Also stick the crude rubber at the side edges of the mat sections, at a length of 40mm-50mm (depending on the type of the DB mat)
- Lay the 2 mat sections into the lower part of the vulcanisation form
- Cover the 2 mat sections with crude rubber strips about 40mm to 50mm wide

Fig.7: Humbolthafen Berlin, Germany: Vulcanised T-piece that is being prepared to receive another vulcanised butt joint connection on site with a longitudinal DB joint.

7. Insert the threaded rods into the clamping devices und clamp until the vulcanisation butt joint fits exactly.

8. Place the upper part of the vulcanisation form. Take care that the mat section remains put in the form.

9. Mount the upper part of the heating form and pull the heating form together by means of the clamping screws. Take care that the mat section remain in correct position.

10. Connect the heating form to the electricity and leave it connected for 3 hours.

11. After 3 hours switch off electricity and let the vulcanised butt cool down for about 30 minutes. Then dismantle vulcanisation form, but not the clamping devices.

12. After another 30 minutes, remove the clamping devices.

13. If necessary, clean the edges.

6. Required tools for the installation of DB mats of type DB40, DB80, and DB130

a) for vulcanising

- heating form
- heating plates
- clamping frame (Korea)
- cutting template
- knife
- 2 clamping devices
- Hammer
- Drilling machine
- Roughening tool (like wire brush)
- Plugs of 8mm and 15mm diameter
- Cleansing liquid (Dytex in Germany)
- 2 brushes
- Crude rubber (both solid and liquid)
- Scissors
- Ring wrenches: 2 x 19 / 2 x 24
- 2 big screw drivers

b) for installation

- Marking pencil
- Mounting tool
- Electric screw driver + Nut 24mm,
- Dynamometric key (torque) + Nut M24, turning moment 200 Nm
- Paraffine Oil
- Plastic hammer
- Hole gauge 18mm

7 Presetting the expansion joints of type DB40, DB80, DB130

Presetting of the DB-joints can be made both in the workshop and at site.
Usually, presetting is done in negative direction, i.e. the joint will be compressed. Resulting from pre-setting in negative direction any movements from creep and shrinkage can be corrected.

Whereas compressing the mats is possible on site, extending the mats to a required presetting cannot be carried out, because the restoring forces make it all but impossible to place the clamping sections over the shot bolts such that the nuts can be properly prestressed.

The amount of presetting that is required depends on many factors, like the age of the concrete, and temperature at time of installation. In certain cases, it is the required presetting that determines the size of a DB mat.

The following maximum presettings can be realised:

	site	workshop
DB 40	- 10 mm	- 15 mm
DB 80	- 15 mm	- 25 mm
DB 130	- 20 mm	- 35 mm

Presetting the mats with the help of clamping tools is shown below:

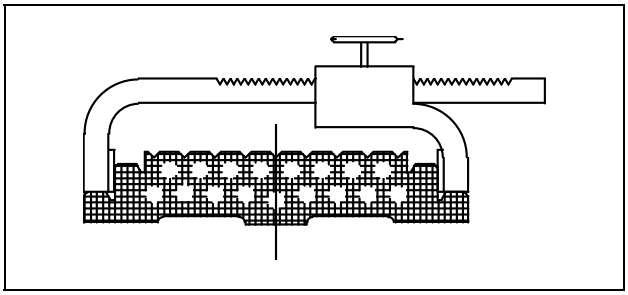

Fig.8: Clamping device for compressing the mat for presetting

MAURER DB Joints Manufacturing and Installation Instruction

8. Connection to Longitudinal Joints

Generally, the same type of DB mats can be connected by means of a T-piece connection to the cross DB joint (see Fig 7).

In addition, Maurer has another longitudinal railway joint in their scope of supply that represents a more economic solution, while being fully functional.

This longitudinal railway joint can accomodate vertical movements of up to 25mm, and the tolerable cross movement is 10mm.

The longitudinal joint has to be connected to the underlying structure by means of a hot bituminous glue. The depth of the concrete that will be placed on top of the longitudinal joint is usually 60mm. In case of High Speed Railway tracks, the depth shall be 80mm.

Like the DB mats, this longitudinal joint as shown below enjoys the approval of the German Railways.

Fig.9: A conventional longitudinal joint connected to a DB mat (Humboldthafen Berlin, Germany)

9. Reference Projects

Among the many projects so far carried out with DB mats, we would like to cite 3 major projects that all cater for High Speed Trains:

- Lehrter Bahnhof and Humboldtbrücke, Berlin, Germany: The biggest interchange railway station in Europe, catering for all kinds of trains, including the ICE train, the German High Speed Train
- Ludwigshafen Station
- Seoul - Pusan High Speed Railway

A comprehensive list of all DB mat reference projects is available upon request.

Fig. 10: Humbolthafen Berlin Germany, DB80 Railway Joint. In the background the Reichstag, the German National Assembly Hall

10 Tests

- Fatigue Test of the Shot Bolting Connection, carried out at the „Prüfamt für den Bau von Landverkehrs-wegen“ in the Technical University of Munich in September 1999

Fig. 11: Maurer DB80 Railway Joint, Seoul - Pusan High Speed Railway, Korea

11 Approvals

The Maurer DB Railway Joints are approved by the German Railways for the use in both „ordinary“ railway projects and High Speed Railway Projects. Maurer Standard drawings are listed in the paper DS804.9030 of the German Railways. This paper refers to standard drawings for railway bridges and road bridges. Maurer Standard Drawings are listed therein as follows:

Standard Drawing No.	Refers to Maurer Joint
MBR1965	DB40 (+/-20mm movement)
MBR1966	DB80 (+/-40mm movement)
MBR1967	DB130 (+/-65mm movement)
MBR1968	Watertight longitudinal joint
MBR1969	Connection between a DB joint and a longitudinal joint

Apart from these standard drawings, a combination of 2 DB80 joints caters to a maximum movement for 160mm, and a combination of 2 DB130 joints (in series) has a 260mm movement capacity. Although not listed as standard drawing, Maurer enjoys a project based approval of the German Railways for the application of these joints.

MAURER Standard Drawings as listed above can be procured by directly writing to

Maurer Söhne GmbH & Co. KG
Bridge Accessories Division
Frankfurter Ring 193
80807 Munich, Germany

Fax: ++49 89 32394 306
Phone: ++49 89 32394 271